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ABSTRACT

Presented is a collection of research reports of college-age investigators. The work of the students demonstrates one way in which reliable and illuminating data on local problems of societal importance can be gathered and analyzed in relatively short time-spans for very little money. Water-related studies, health-related and basic environmental studies are presented in abstract form. Included in each paper are the college in which the student investigators were enrolled, the participants in each particular research endeavor, the student project director, and faculty advisor. (EB)

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STUDENT-ORIGINATED STUDIES PROJECTS

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1973

Abstract Reports

Presented at Meetings
in Washington, D.C.
December 26-29, 1973

NATIONAL SCIENCE FOUNDATION
Washington, D.C. 20550

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Edited by BERTON F. HILL

NATIONAL SCIENCE FOUNDATION
Washington, D.C. 20550

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FOREWORD

The reader of the abstracts that follow likely will be struck, as I have been, by three significant lessons to be learned from Student-Originated Studies:

(a) College-age investigators are exhibiting admirable maturity—educational, scientific and personal—as their SOS teams come to grips with genuinely difficult and challenging problems. There is a moral here for those on the Nation's campuses who bear responsibility for the effectiveness of the science curricula in our colleges and universities. These students are revealing their readiness for educational efforts the rigor and depth of which are all too rarely found in undergraduate classroom-laboratory work.

(b) These groups of developing young scientists are demonstrating one way in which highly reliable and illuminating data on local problems of societal importance can be gathered and analyzed in relatively short time-spans for very little money. They present a source of skilled, highly motivated and under-utilized manpower—available for work on short-term issue-oriented topics—to public decision-makers who are constantly harrassed by the necessity for resolving technical issues in the absence of adequate data.

(c) Interdisciplinary teams of student investigators are demonstrating that objectives and strictures that initially appear to be mutually exclusive can often be reconciled. Appropriate mixtures of social, physical, life, engineering and environmental scientists can be very effective in marshalling together hard facts from their several vantage points and then in cooperatively seeking an optimized solution. There is reassurance here for our National society that often seems dismayed over the complexity of the problems that arise out of our technological age.

For these three lessons the Foundation extends its thanks to the seven hundred and fifty participants who directed the efforts of their 79 projects toward the diverse problems chronicled in the following pages. Their ability, industry and perseverance have earned our sincerest commendation. We wish to each of them the benefits described as accruing to SOS participants in a recent issue of *The Journal of College Science Teaching:*

> "(Most) participants return to their formal studies with new motivation, self-confidence, and sense of purpose. It is not just their facility with lab instruments that is impressive. It is the sudden blossoming of their "scientific maturity"—their appreciation of the nature and value of evidence, their tenacity in pursuit of a question, their disciplined imagination; in sum, the fruits of their first success as scientific investigators. These are youngsters who have seen their tentative commitment to scientific careers fully confirmed. In a significant way, they've already launched upon them."

H. Guyford Stever
Director

Section I.

Water-Related Studies

Papers from Heidelberg College, Weber State College, Cornell University, Central University of Iowa, Benedictine College, Delta State College, Central Missouri State University, University of New Hampshire, University of South Florida, University of North Carolina at Asheville, Southwest Minnesota State College, Colorado School of Mines, Luther College, Minot State College, Illinois Institute of Technology, Hiram College, St. Mary's Dominican College, Ripon College, Massachusetts Institute of Technology, North Dakota State University, University of Miami, University of Idaho, State University of New York at Binghampton, Sam Houston State University, Northern Illinois University, University of Washington, University of Hawaii, and the University of South Carolina.

Significance and Characteristics of Phosphates in an Agricultural Watershed (Grant no. GY-10758)

Heidelberg College
Tiffin, Ohio 44883

May 28, 1973 - August 10, 1973

Participants:

Clint Beckert	Richard Murbach
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*Student Project Director

David Baker, Faculty Advisor

The increasing rate of eutrophication of Lake Erie has been attributed to phosphates. In a predominately agricultural area, much of the phosphate contribution to the surrounding waters comes from diffuse sources. Some of these are erosion, feed-lot run-off, septic tank effluent and surface run-off from fields. The exact locations of these phosphate contributors are difficult to pinpoint; to attempt to treat them with a phosphate removal system, such as one does with municipal point sources, is impossible. Once the nutrient is in the water, one would have to treat the whole body of water, be it stream or lake, to extract it.

Ohio has a law which requires all cities with a wastewater flow of one million or more gallons per day to have a phosphate removal system in operation by January 1, 1974. This is a reasonable solution in the industralized city. This group questions the effectiveness of such a system in an agricultural area like the Sandusky River Basin. It was felt that, although such a system deals with part of the phosphate problem, it is not the most efficient means to use for this area. The study conducted at Heidelberg College attempted to prove this hypothesis and to suggest an alternative for reducing the contribution of phosphates, and slowing the rate of eutrophication of Lake Erie. For this purpose, the project has three sections, chemistry, algae, and economics.

The chemistry section monitored the phosphorus (soluble orthophosphorus and total phosphorus) input into the Sandusky River from the Upper Sandusky Waste Water Treatment Plant, with and without phosphorus removal facilities in operation. During the nine-week sampling period, the phosphorus removal facilities were turned off for two two-week periods. Daily samples were taken upstream and downstream from the treatment plant to examine phosphorus levels in the river. Phosphorus levels in Tymochtee Creek (the major tributary in the study area) were also monitored.

Three methods of sampling were used throughout the course of the study: grab sampling, sequential sampling and composite sampling. Grab samples comprised the majority of the specimens obtained. One sample was taken every day at each of the nine sites located along the Sandusky River, two sites at the treatment plant (influent and effluent), and Tymochtee Creek. Flow measurements were also taken at the three United States Geological Survey stream gauge stations located at the sites. Flow measurements were also obtained for the treatment plant.

The analysis of the water specimens included a determination of soluble orthophosphorus, total phosphorus, total suspended solids, pH conductivity. Analytical techniques followed the methods established in: Methods for Chemical Analysis of Water and Wastes (EPA, 1971).

The chemistry section determined the efficiency and loading of the treatment plant, the phosphorus and suspended sediment variations in the river (in relation to its flow), the relation of phosphorus and suspended sediments and the possible instream benefits of phosphorus removal.

To determine whether instream benefits can be derived from the installation of phosphorus removal systems at municipal wastewater treatment plants in agricultural watersheds, it is necessary to consider how much phosphorus the plants contribute to the phosphorus levels in the river. Only 6% of the soluble orthophosphorus flux and .77% of the total phosphorus flux which passed the site immediately downstream from the treatment plant (1.94 miles) could be attributed to effluent from the treatment plant. These values decreased for the farthest site downstream (38.5 miles). Thus, sources other than this effluent should be viewed as the major sources of phosphorus input to the Sandusky River.

The algae section collected samples every third day, simultaneously with the chemistry collection. Algae were sampled at eleven locations, one upstream and eight downstream from the treatment plant, and two on Tymochtee Creek. In addition to the regular plankton and river collections, benthic samples from an artificial substrate were collected every six days. All identifications were made taxonomically to genus.

The algae section counted phytoplankton and diatoms, made a chlorophyll analysis of artificial substrate and phytoplankton, and determined biomass and artificial substrate phosphates. These parameters were measured to determine quantitatively if phosphate removal from a domestic source is effective in limiting algae growth.

The lotic phytoplankton was sampled by pouring 32 liters of surface water through a Wisconsin Style Plankton Net for concentration. Identification, cell counts, and chlorophyll analysis were conducted. The chlorophyll analysis procedure is described in Algae, Man and the Environment (edited by Daniel F. Jackson). The counting and identification of samples were performed by the Sedgwich-Rafter chamber method. The benthic diatom specimens were collected just above the water. These samples were diluted and a portion transferred for collection on a .45μ membrane filter. The diatoms were cleared with cedarwood oil and counts were made. The artificial substrates were provided to quantify further the growth of algae in the river. Biomass, chlorophyll analysis and orthophosphates tests were conducted on the artificial substrate slides every sixth day.

The data show that the plankton and diatom counts, and the artificial substrate determinations were higher during low flow periods. The data also indicate that there is no correlation between the quantity of algae in the section of river sampled and the activation of the phosphate removal at the treatment plant.

The economic section of the project had two-fold responsibility. First, the cost-effectiveness of the phosphate removal system at the Upper Sandusky treatment plant was determined. This plant is in an agricultural area so the study yielded a reasonable idea of the effectiveness of the phosphate removal system planned for Tiffin. This included a study of the effects of different levels of phosphate contribution on eutrophication of Lake Erie. Water quality control standards for Ohio were also reviewed.

Part two of the study tried to find an alternative method of phosphate contribution control. Visits were made and interviews conducted at the Soil Conservation Service, Agricultural Extension Service, the Ohio Agricultural Research and Development Center at Wooster, and the United States Department of Agricultural Research Center at Coshocton. It was determined that the prevention of phosphate contribution was the best solution, rather than trying to treat the problem after the phosphates had entered the water. A comprehensive watershed management authority is suggested. This body would make a detailed study of the area and "tailor-make" a program which fits this area. This would include soil tests and a total land-use planning program.

Reference copy: Heidelberg College Library

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An Evaluation of the Importance of Ephydra cinerea to the Ecosystem of the Great Salt Lake (Grant no. GY-10775)

Weber State College
Ogden, Utah 84403

June 11, 1973 - August 30, 1973

Participants:

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The brine fly, *Ephydra sp*. (Diptera: Ephydridae), creates a nuisance for the recreational and industrial facilities on the Great Salt Lake. This problem has caused the State of Utah to initiate control measures which involve yearly expenditures of forty to fifty thousand dollars. Some interest groups call for the total eradication of the brine fly.

It is a general rule in insect control to study all phases of the target insect's life cycle and general biology and attack it at its most vulnerable point, providing however, that the importance of the insect as a pest or health hazard outweighs the importance of the insect to its ecosystem. An extensive literature review made by members of this research team has revealed very little information on the general biology and life cycle of the genus, *Ephydra*. For these reasons, an interdisciplinary study of the life cycle and general biology of the brine fly and its importance to the ecosystem of Antelope Island State Park was proposed for the summer of 1973.

The team was divided into three areas of study: botanical, invertebrate, and vertebrate.

The life cycle and biology of E. cinerea were determined under laboratory conditions approximating those in nature. Field observations were also made when feasible.

E. cinerea undergoes a complete metamorphosis. The females deposit about 34 yellow eggs which measure approximately 0.6mm X 0.18mm. These eggs, in small clusters, slowly turn light brown and hatch at around 58 hours at 80°F.

Larvae have 8 pair of prolegs, are lightly pigmented and almost translucent, with an anal tube sometimes measuring as much as 1/3 of the larva's body length. Three larval instars were determined. The first stadium was 16 days, the second was 25 days, and the third, 18 days.

A simple method of analyzing and quantifying the composition of gut contents of several species of larvae was devised. Bottom sediment samples were taken from different areas of the Great Salt Lake in an attempt to get a good cross-section of habitats. Quantification of food was presented in the form of percentages, with differences between habitat and trophic levels explained when possible. Ephydra larvae seemed to be generalists in feeding habits, with bacteria associated with non-living organic matter being of primary preference.

Areal distribution of several species of Ephydra larvae was determined qualitatively from bottom sample sites. Algal, as well as larval, content was analyzed from these sites. The algae included several different genera of blue-green algae, as well as some diatoms. One genus of blue-green algae appeared to be an epithelial oscillatory attached to the brine fly larvae.

Prior to pupation, a slight thickening of the area about the prolegs occurs, after which the third instar exocuticle becomes the pupal skin and turns from a grayish-white to a golden brown color. The pupae attach themselves to substrata by the anal tube, utilizing its basal and apical fork. The time spent in this stage was 9 to 10 days.

Adult E. cinerea lived from 1 to 6 days; the majority (86.01%) lived 3 to 5 days. Only males survived as long as 6 days. No courtship ritual nor territorial behavior was observed.

Females, after mating once, would not allow other males to mate with her for a period of time. The males, however, would attempt to mount other females immediately after copulation.

An adult species diversity index was also established at sites on the island. Species diversity seemed to correlate with salinity of habitat.

The total life span of the laboratory-reared E. cinerea was 65 days. Under laboratory conditions, this may not represent the true life span. Field life span data could not be determined because of the cost/time budget of the study and the overall difficulty of sampling the harsh environment of the lake.

The vertebrate study consisted of two phases: taxonomy of the vertebrates found on the island, and a food habit analysis to determine which vertebrates were feeding on the brine fly.

Ten species of mammals, 32 bird species, and five species of reptiles were observed directly. Of these, one mammal species and two species of birds had not previously been reported on Antelope Island. Reports of observations by reliable sources, especially the park ranger, added another seven species of mammals to the totals. A literature search increased the species of mammals by one, and two introduced species are also included. The total number for each group reported in this study are, therefore, 20 species of mammals, 32 bird species, and five species of reptiles.

Data concerning food habits of the mammals and reptiles were obtained through laboratory observation and stomach content analysis.

The mammals and reptiles studied in the laboratory seemed to be omnivorists and did not appear to prefer one food to another. It was observed, however, that for the small mammals studied, large numbers of brine flies were necessary (in excess of 100 ml/day) for them to maintain constant weight.

The only reptile found to eat the brine fly was Uta stansburiana. Four species of mammals, Peromyscus maniculatus, Microtus pennsylvanicus, Perognathus parvus, and Reithrodontomys megalotis, were shown to be feeding directly on the adult brine fly. Of these, Peromyscus maniculatus had the largest numbers of brine flies in their stomach contents.

Food habit data for the avifauna were obtained both by direct field observation and by the salvaging of dead specimens for stomach content analysis. Three bird species were found to be feeding on the brine fly. These were Wilson's phalaropes, California gulls, and western meadowlarks. Other species of birds reported in this study may be potential or actual predators of the brine fly. One, in particular, the snowy plover, has been reported to feed extensively, if not exclusively, on E. cinerea.

This summer's preliminary investigations indicate that brine flies play an important role as nutrient recyclers in the ecosystem of the Great Salt Lake. The stage most susceptible to control is that of the adult. The egg, larva and pupa are extremely hardy. The brine fly is a food source for members of each major vertebrate group found on Antelope Island. Some members appear to be feeding extensively on the brine fly during the summer months. Many of the vertebrate species found on the island, such as the short-eared owl, marsh hawk, raven, bobcat, and various snakes, are secondary and tertiary members of the food web associated with the brine fly.

The imago, although a very important link in the food chain, could possibly be controlled (with little overall effect on the ecosystem), providing the control does not exceed certain limits. It is one thing to control the fly population on the bathing beaches and quite another to attempt to control the entire population of the lake. "Shotgun" insecticides should be examined very carefully before extensive use is made of them for control measures. Perhaps the use of chemosterilants on the male fly is feasible, since it was observed that the female rejected male suitors after copulation occurred. Studies in this area, as well as on the emergence and population of the brine fly, are needed.

Reference copy: Weber State College Library

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A Quantitative and Qualitative Analysis of Fall Creek

(Grant no. GY-10805)

Cornell University
Ithaca, New York 14850

May 26, 1973 - September 1, 1973

Participants:

Dennis Adler	Lee Palmer
Margaret Fallon	Joseph Rosen
Thomas Grenninger	David Schwartz*
Ed Moczydlowski	John Zimmerman

*Student Project Director

Paul J. VanDemark, Faculty Advisor

Fall Creek flows from an area 35 miles north of Cayuga Lake, near Lake Como in Cortland County, into Cayuga Lake at Ithaca (Tompkins County). By means of quantitative analysis, we attempted to determine the actual amount of specific pollutants. By means of qualitative analysis, we tried to determine the specific pollutants found in Fall Creek. Microbiologically, we were concerned with the most probable number of fecal coliforms and fecal streptococci. In the area of chemistry, we were concerned with the results of the following specific tests: nitrate, nitrite, ammonia, total organic nitrogen, ortho-phosphorous, total phosphorous, chemical oxygen demand, biochemical oxygen demand, dissolved oxygen, dissolved solids, alkalinity, pH, chloride, calcium and hardness. We also attempted to analyze the viral levels within the Fall Creek watershed. The numbers of coliphage correlated well with the numbers of coliform during good weather, but during inclement weather, the findings were not as accurate. We attempted to determine the presence of human viruses in the creek by growing them on human and monkey kidney cells.

During the twelve-week period, we completed seven sampling runs, covering Fall Creek from its mouth to its sources, in an effort to establish a basic profile of the water system, and to detect sites suitable for detailed examination. In general, the Creek appears to be well-aerated, but it shows an increase in specific chemical components as it enters the more populated, industrialized area near its mouth. There are also concentration differences between the two branches of the water system, Fall Creek and Virgil Creek, and definite level increases after it passes some of the small towns situated along Fall Creek. Most of the levels of the chemical components that we have examined seem to be within acceptable limits, and thus may serve to provide a representative example of a "clean" water system, as well as establishing a reference for future comparisons by the community.

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We have tested individual point sources of possible contamination in a variety of ways, including such techniques as the daily sampling of an area for a specified time period, and sampling at short distance intervals downstream from a source. Some of our point sources were trailer park outlets, pipe effluents, industrial effluents, swamps, tributaries to the main creek, and the Lake Como area which has come under public scrutiny recently.

At this point, we can conclude that the Fall Creek Water Basin is generally a "clean" water system with relatively low levels of the pollutants we have studied. We have found, however, certain areas of the system to be higher in some pollutants than others.

Reference copy: Olin Library, Cornell University

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Establishment of Physical-Chemical-Biological Parameters for Red Rock Reservoir (Grant no. GY-10800)

Central University of Iowa
Pella, Iowa 50219

May 28, 1973 - August 4, 1973

Participants:

Kevin Curry	Les Hook
Terri Broxmeyer	Jane Lowe
Beverly Hinkle*	Jan Palmer
Patsy Hoekstra	Helen Wichhart

*Student Project Director

John B. Bowles, Faculty Advisor

The primary purpose of this study was to investigate the status of the Red Rock Reservoir in terms of its biological, chemical, and physical components. Secondary aims were to familiarize students with standard techniques employed in water quality analysis, to initiate interest in further studies, and to aid concerned civic groups in making major decisions about the study area.

Volumetric water samples were collected twice a week during the investigation at eight different sites and three depths. Sample collections were made with a 1200 ml Kemmerer water sampler. Water temperatures and Secchi disk readings were recorded. Dissolved oxygen samples were fixed with manganous sulfate and alkaline-iodide azide in the field. The Hach DR-EL Kit was used in analyzing samples for nitrate (cadmium reduction method), nitrite (diazotization method), and total and ortho phosphates (StannaVer method). Titration methods were used to determine levels of total alkalinity, acidity (phenophthalein), free carbon dioxide, calcium (EDTA), magnesium (EDTA), and dissolved oxygen and BOD (azide modification of Winkler method). Ammonia nitrogen (direct Nesslerization), total iron (1.10 phenanthroline method), and turbidity (formazine standard) levels were determined spectrophotometrically. The Millipore membrane filter technique using m-Endo broth was employed for total coliform colony counts Individual zooplankton and phytoplankton were counted using dissecting and Nikon phase microscopes, respectively. Thin layer chromatography was employed for the detection of pesticide residues. Identification of chlorinated hydrocarbons was based on R_{TDE} values of standards run concurrently with samples. Data were tabled, graphed, and analyzed by multiple regression techniques to determine possible correlations between biological and chemical parameters.

The following summary gives the ranges recorded for the various chemical and physical parameters.

Parameter	Range
Water temperature	13.0 - 28.0 C
Turbidity	4 - 180 JTU
Light penetration (Secchi)	0.38 - 5.49 m
pH	6.68 - 8.24
Acidity	0.0 - 14.4 mg/l $CaCO_3$
CO_2	0.00 - 16.76 mg/l $CaCo_3$
Total alkalinity	125 - 257 mg/l $CaCO_3$
Calcium	102 - 210 mg/l $CaCO_3$
Magnesium	47 - 159 mg/l $CaCO_3$
Total iron	0.00 - 1.00 mg Fe/l
Ammonia nitrogen	0.00 - 2.43 ppm
Nitrate	15 - 45 ppm NO_3
Nitrite	0.20 - 1.68 ppm NO_2
Total phosphates	2.8 - 17.2 ppm
Orthophosphates	0.22 - 1.55 ppm
DO	0.5 - 9.0 ppm
BOD	0.0 - 4.5 ppm

Phytoplankton and zooplankton counts were low. The only significant bloom to occur was on July 16th when large numbers of *Carteria* suddenly appeared. The major phytoplankton identified were *Volvox*, *Sphaerocytis*, *Ceratium*, *Characium*, *Botrydiopsis*, *Asterionella*, *Pediastrum*, *Cosmarium*, *Gloeocystis*, and *Carteria*. The major zooplankton identified were *Cyclops bicuspidatus*, *Bosmina longirostris*, *B. coregoni*, *Daphnia pulex*, *D. ambigua*, *D. dubia*, *D. galeata*, and *Moina micura*. Coliform were present. However, no distinction was made between fecal and nonfecal types. Pesticide residues of chlorinated hydrocarbons were not detected by the method used. Spots that did appear on the TLC plates did not correspond with the standard R_{TDE} values.

In general, the water quality of the Red Rock Reservoir appeared to be satisfactory. Differences were mainly between depths rather than sites. Chemical constituents for the most part were below harmful limits. Nitrates, nitrites, and phosphates possibly warrant further study, as levels were higher than might be expected. The low numbers of phytoplankton and zooplankton may have been a result of the heavy rainfall received during June and July and the constant fluctuation of the conservation pool level. Correlations between biological and chemical-physical parameters ranged from none to slight. More biological data were needed. Pesticide residues probably were present, but more likely to be in the sediments. The TLC method used needs refinement. Further study groups may want to monitor specific streams or runoff areas entering the lake, to continue testing for pesticides with emphasis on sediments, and to sample more frequently for zooplankton and phytoplankton.

Reference copy: Central College Library

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Net Primary Productivity and Related Parameters in Perry Reservoir

(Grant no. GY-10776)

Benedictine College
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June 4, 1973 - August 10, 1973

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This SOS project attempted to determine the level of primary productivity in Perry Reservoir, along with related physical, biological, and chemical parameters. Correlation of the results with previous studies on Perry was to be carried out at the end of the summer, following the completion of the water sampling and testing. The project also was intended to be an indication of pollution in selected areas of questionable effluence which were suggested by the Army Corps manager at Perry.

Water samples from each of eight selected sites were collected six times throughout the summer. The tests performed were:

Biological Tests	Chemical Tests	Physical Tests
Primary Productivity	Phosphorus	Air & Water Temperature
Phytoplankton	Nitrates	Turbidity
Chlorophyll a	Nitrites	pH
Total Coliform	C.O.D.	Dissolved Oxygen
Fecal Coliform	B.O.D.	Total Dissolved Solids
Biomass-residue	Total Alkalinities	Barometric Pressure
		Cloud Cover
		Conductivity

All the chemical tests and the biomass-residue test employed procedures taken from Standard Methods for the Examination of Water and Wastewater, 13th Edition. The physical tests were performed using standard laboratory instruments. The coliform tests and chlorophyll a determinations were made using regular counting procedures, and the primary productivity level was obtained using a method developed by Steeman-Nielson utilizing ^{14}C.

After obtaining the data, the individuals who performed the tests were responsible for correlating with primary productivity and previous studies of Perry Reservoir.

Definite conclusions reached as a result of the study are:

1. No single limiting factor for primary productivity in Perry Reservoir could be established among the parameters studied. Rather, it is thought that a combination of these parameters determined the limit.

2. Phytoplankton, chlorophyll a concentrations, and the primary productivity level, were higher in the northern regions of Perry Reservoir, and declined southward towards the dam. In other words, inflow waters affected the organisms in the lake.

3. Increase in bacterial populations was in direct proportion to increases of rainfall, nitrite, and phosphates, indicating that run-off from the land and from river waters flowing into the lake do have specific effects upon the lake.

4. As a young lake, Perry is quite productive because of the release of nutrients accumulated in the basin prior to impoundment; as a result, productivity levels are approximately upper mesotrophic. However, this state is expected to change in time and proceed to a more fixed state of declined productivity in which more care must be taken to preserve water quality.

5. More extensive tests, including those dealing with turbidity effects, need to be performed to analyse more completely the process of primary productivity at Perry Reservoir.

Reference copy: Libraries of Benedictine College

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Investigation of Environmental Stress of the Cleveland Lagoon System (Grant no. GY-10785)

Delta State College
Cleveland, Mississippi 38732

May 28, 1973 - August 17, 1973

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This study was designed to investigate the chemical and biological parameters of the Cleveland lagoon system and their impact on the Sunflower River. In this project, emphasis was placed on working toward a common goal by cooperation between the City of Cleveland and Delta State College students. A majority of our procedures was obtained from Standard Methods. Before we employed any alternate procedure, research material on the test was studied and the advice of Clark, Dietz, and Associates, Inc., an environmental firm in Jackson, Mississippi, was obtained. Both biological and chemical samples were taken in the morning between the hours of 8:30 and 10:30 a.m. During the operation of sample collection, parameters, such as water temperature, air temperature, pH and dissolved oxygen, were measured on location.

Those tests which required fixed laboratory equipment were initiated on the return of the samples. Usually, this laboratory analysis began around 10:45 a.m. and terminated at 4:30 p.m. These tests were conducted on a daily basis which allowed every participant to receive a first-hand working knowledge of every facet in the study.

The findings indicate a valid reduction of biochemical constituents in the range of 60 to 85 percent. The chemical reduction varies among the different parameters. Examples of these are: ammonia nitrogen, 80 to 90%, nitrates, 50 to 60%, specific conductance, 15 to 25 %, phosphate, 10 to 15%. These findings will be used by the City of Cleveland and Clark, Dietz, and Associates, Inc., in the designing of the waste treatment plant to be constructed in the near future.

Reference copy: Mississippi Room, Roberts Memorial Library of Delta State College.

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Concomitant Study: Sewage Effluent, Water Quality, and Regional Planning (Grant no. GY-10797)

Central Missouri State University
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June 4, 1973 - August 14, 1973

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The objectives of this study were to gather information on the impact of municipal sewage on selected parameters of water quality in streams of a three-county region of west Central Missouri; and to make this information available to those persons who were involved in planning for this region. The investigation was concentrated on the Show-Me region of Johnson, Lafayette, and Pettis counties.

To accomplish the stated objectives, the project was subdivided into three phases: (1) Data gathering; (2) Data Compilation; (3) Analysis, report preparation, and dissemination.

Eight weeks were allotted to date gathering; two weeks to the writing of status reports and report write-up and dissemination of data. Two field teams gathered water samples, ran field tests, took field notes at each collecting station, and took pictures. The laboratory team completed the analysis of the samples on tests that could not be performed in the field.

The data gathered consisted of two types: (1) field and laboratory, and, (2) information that had been filed with the Missouri Clean Water Commission.

It was found that there were 24 municipalities, each with over 200 population, which had sewage facilities emptying into the stream systems of this region. The basic plan of organization for the field sampling followed the suggestion of Makenthum and Ingram (1967) and others. Operating under the hypothesis that no difference should exist between samples, points were plotted upstream and downstream from a source of possible pollution. Additional samples were taken downstream from potential points of impact, at the junction of other stream systems, and downstream to the limit of our study area on the Blackwater River. There were a total of 118 sampling stations and each station was visited twice. Physico-chemical and biological field data were the primary foci of this study.

The monthly-report forms that each municipality were required to file with the Missouri Clean Water Commission were examined for the 24 municipalities. In addition, more complete and detailed records on each municipality's sewage facility were

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compiled. Data such as the year the sewage facility began, year revised, the population served, kind of treatment, and permit number were available to us.

Analysis of the data was made by comparisons of upstream-downstream values. These comparisons were categorized into the following subdivisions: upstream-downstream values for each municipality; u-d values associated with a particular watershed; u-d values related to each county; and u-d values for the total Blackwater River Basin within the area.

Data were plotted in graphs and grouped into tables for each parameter of each subdivision listed above. Dissemination and presentation of our findings took place on August 14, 1973, at which time we held a public meeting for all interested persons. Special invitations were sent to the following:

Missouri Clean Water Commission
Missouri Division of Health
Missouri Water Resources Board
Show-Me Regional Planning Commission
County judges of Johnson, Lafayette, and Pettis counties
Region-Seven Office of the Environmental Protection Agency
Mayors and/or City Councils of the 24 municipalities
Environmental Education Commission of the State of Missouri
Missouri Department of Conservation

In addition, news releases were submitted to each of the newspapers serving the municipalities.

After the examination of data from each municipality, county, watershed, and the total Blackwater River Basin, it was found that unusually high values for phosphates were found in these stream systems. This increases the growth rate of algae and aquatic fauna which, in turn, increases the oxygen demand on a stream system. Low values for dissolved oxygen (<4 ppm) were found downstream from many of the municipal plants and in slow-moving waters. Bacterial counts were significant when compared with Federal accepted criteria, with high values greater than 2 billion/100 ml. These counts were high both upstream and downstream from an effluent, but a significant difference did exist between these stations.

It was found that municipalities were definitely having an impact on these stream systems as a result of the sewage affluent entering the streams. Improvements could be made in the existing sewage treatment plants. In addition, stronger enforcement of the operation of sewage facilities and of the accuracy of report form completion is necessary. Much improvement must be made on these systems and the river streams before surface water can be utilized for domestic purposes on a large scale.

A copy of the report was given to each person attending the meeting and a copy was mailed to each city or county unit not represented.

Reference copy: Library of Central Missouri State University.

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The Cocheco River: Its Composition and Effect on the Community

(Grant no. GY-10783)

University of New Hampshire
Durham, New Hampshire 03824

June 4, 1973 - August 24, 1973

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The Cocheco River, the focus of the study, was investigated with a number of primary objectives in mind:

1. Determination of the chemical, physical and bacteriological parameters of the stream.
2. Observation of the fluctuations of these parameters, both in space and time.
3. Location of those sources responsible for major changes in stream composition along its length.
4. Investigation of potential consequences of the various stream constituents.
5. Determination of the value of the stream to the community, including future possibilities.
6. Determination of the effects which the community has on the stream.
7. Communication of our findings to those groups or persons involved with or interested in the Cocheco.

The Cocheco River was a good choice for study because of the very small amount of work previously done on it. This investigation provided good data upon which further research can be based.

In order to investigate those parameters involved, 16 sample stations were established along the freshwater portion of the river. According to the importance of their location, these stations were sampled either once or twice weekly. Those tests performed included the following:

Chemical Tests:

- Detergents
- Specific Conductivity
- Dissolved Oxygen
- Biochemical Oxygen Demand
- Chemical Oxygen Demand
- Sulfates
- Chlorides
- Calcium
- Hardness
- Alkalinity
- Orthophosphates
- Total Phosphates
- Ammonia Nitrogen
- Total Nitrogen
- Total Solids
- Dissolved Solids

Physical Tests

- Depth
- Turbidity
- Air Temperature
- Water Temperature
- Flow Rate

Microbiological Tests

- Coliforms
- Fecal Coliforms
- Fecal Streptococci

In addition, 24-hour checks were performed on three occasions, involving 9 sample stations. These were made to monitor diurnal fluctuations. Data were stored in an IBM 360 computer and analyzed statistically at the completion of the project. Contact with the community was maintained continually through a number of meetings with Town officials, State and County environmental agencies, and concerned citizen groups. Town records and publications were also utilized.

Water quality was determined to be extremely poor throughout most of the stream length, municipal sewage being the principal cause. At this time, there is no significant sewage treatment facility in operation. As a result, municipal wastes are being dumped directly into the Cocheco. As indicated by the levels of bacteria, serious public health problems could result. Chemical levels, as shown by our data, also denote a high degree of pollution. Direct industrial inputs were found to be of only secondary importance. It should be noted, however, that most of the industry in the area was connected to the municipal lines and, thus, contributes to this source. (Over the weekend of 7/20/73 - 7/22/73, an extensive fish-kill occurred. It is suspected that an industrial source could have been responsible.) Because of these sources, significant longitudinal fluctuations were observed for chemical, physical, and microbiological constituents. Water quality was shown to be consistently poor below sewage inputs and population centers, but exhibited limited self-purification between these points. Physical parameters demonstrated obvious fluctuations; however, correlations with chemical factors are not yet complete. Temporal fluctuations were also found to be significant.

Population increases for those towns along the river ranged from 9.0% to 23.0% between 1960 and 1970. This increased population could, without proper planning, add to already existing problems. Because of Environmental Protection Agency requirements, Farmington, Rochester and Dover must have, by 1977, sewage facilities capable of performing secondary treatment. This would be the most important step toward improving the water quality of the Cocheco River. Once this is done, the sand and gravel composition of the stream bed will enhance self-purification. Present concern for water quality in this region has initiated plans for increased sewage abatement, formation of recreation areas, and the designation of certain lands as natural areas.

Reference copy: University of New Hampshire Library

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A Study of the Biology, Ecology, Extraction and Economics of Hypnea musciformis (Wulfen) Lamouroux (Rhodophyta: Gigartinales)

(Grant no. GY-10819)

University of South Florida
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June 8, 1973 - September 20, 1973

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A study of the biology, ecology, extraction and economics of the marine red algae, Hypnea musciformis (Wulfen) Lamouroux was undertaken at the University of South Florida Marine Science Institute in St. Petersburg, Florida. The objective of this research was to find ways of utilizing domestic waste products (secondary-treated sewage effluent) in a productive manner so that it need not be a source of pollution for Tampa Bay. Hypnea musciformis grows well in these polluted waters and has a mean increase in biomass of 20% per day. Contained within the cell walls of Hypnea musciformis and other red algae are polysaccharides which can be extracted and processed to yield carrageenin, a substance which has broad uses as emulsifiers, stabilizers, and controllers of flavor, moisture, texture, and appearance in the food industry, especially the dairy industry. The demand for carrageenin far exceeds its availability and large scale mariculture should prove very profitable.

Since little research has been conducted on Hypnea musciformis, our program followed two main directions. The first, a study of the biology and ecology of Hypnea included examinations of the natural distribution, grazing, in situ growth rates in relation to physico-chemical parameters, field culture using a large circulating sea water system, and optimal growth rates using controlled laboratory culture techniques. The second part of the work was the extraction and analysis of carrageenin from Hypnea musciformis. Two additional studies were also completed: economics of the algae industry, and design of large scale culture systems.

This research has shown that quantification of actual grazing by vertebrates and invertebrates at experimental sites was unfruitful. Hypnea plants were placed in monofilament net bags and compared with unprotected Hypnea plants. Hypnea was able to overcome the small grazing effect (25%) and, a significant yield was still recognized (39% increase in biomass).

At the experimental field sites, Hypnea fragments were placed on square algae racks and growth rates were determined. From August 7, 1973 to August 10, 1973, Hypnea showed an increase of 210% over initial weight. In the following three-day period, however, only a 60% increase over the first period was realized. In the third three day period growth tapered off further and, in some cases, weight values decreased, possibly due to grazing. The nutrient levels measured by a Technicon II Auto Analyzer remained uniform, with means of 0.0007, 0.0087, 0.036, 1.26 mg/liter for NO_2, NO_3, NH_3, PO_4, respectively. Temperatures ranged from 28°C to 30°C for the study period. Vandalism repeatedly interrupted experiments, such that long-term data for single Hypnea plants was unobtainable.

The most promising results were obtained from the constant circulating sea water system. Detached Hypnea plants were tagged and placed in a sea water system and constantly tumbled by direct pumping of Bay sea water. Percent increase from initial weight ranged from 463% to 1505% for a ten-day period. Nutrients remained uniform with means of 0.0022, 0.0083, 0.076 mg/liter for NO_2, NO_3, and NH_3, respectively. Temperatures ranged from 28°C to 30°C. Comparison of nutrient data and growth data for static stations and the circulating system indicates that the nutrient levels are similar, but growth is much greater in the circulating system, indicating that circulation aids growth significantly.

Laboratory investigation followed two lines of experimentation: (1) photoperiod, light intensity and nutrients, and (2) temperature. Detached *Hypnea musciformis* plants were cultivated in tanks supplied with both flowing Tampa Bay sea water and artificial sea water (Instant Ocean Mix). Temperatures for both systems ranged from 23°C to 26°C. Growth was measured twice weekly and weights were recorded as mean percent increase. Maximum weight increases were obtained for Bay water plants under a $12:\overline{12}$ photoperiod at a mean illumination of 625 foot-candles. A $16:\overline{6}$ photoperiod was also effective in promoting rapid growth at a 200 foot-candle intensity.

Temperature studies show that the growth of *Hypnea* is directly related to temperature. Optimal growth occurred at 28°C with significantly poorer growth at 18°C and 33°C. These growth rate results are extremely important when looking at the economic potential of *Hypnea* on a yearly basis. Possible channeling of thermal discharges from power stations into *Hypnea* farms would make the year-round cultivation of *Hypnea* feasible.

The second major phase of this study was the extraction and analysis of carrageenin from *Hypnea musciformis*. Fresh *Hypnea* plants were washed, dried and k-carrageenin, a structural polysaccharide, was extracted by autoclaving for 15 minutes at 17 pounds pressure.

The gel contents were extracted from Hypnea in the early part of July and at the end of August. A comparison was made with respect to nutrient levels, salinity, and time of harvest. The early July samples had a significantly greater yield, 266 mg polysaccharide/g dry weight, than did the late August extraction (152 mg polysaccharide/g dry weight). The physical and chemical parameters for the collection times were not significantly different.

Based on the data derived from this study, it appears that the mariculture of Hypnea is both feasible and desirable. It is the participants' opinion that, by the employment of a circulating sea water system, coupled with the ambient levels of nutrients in Tampa Bay and the channeling of thermal effluent, a profit could be realized from the mariculture of *Hypnea musciformis*. It is also suggested that further research is needed and should be performed to substantiate this study's limited results before a mariculture farm is contemplated.

Reference copy: University of South Florida Library

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Biosystem Character of the Pigeon River in the Primary Stage of Recovery (Grant no. GY-10780)

University of North Carolina at Asheville
Asheville, North Carolina 28804

May 20, 1973 - August 12, 1973

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The investigation was conducted to determine the characteristics of the Pigeon River, located in Western North Carolina. The study group, consisting of five biologists and five chemists, sought an evaluation of the pollution controls now existing on the river and a determination of whether further improvements or recovery was possible.

A 30-mile section of the river from its headwaters to Walters Lake was studied. This section was subdivided into areas for sampling and monitoring. The river has two main parts. The upper headwaters, with their origin in the Pisgah National Forest, are "non-polluted" and are in a natural state. The only pollution in the segment from the National Forest to the town of Canton comes from small farms during rain runoffs. Thus, this area became our control and served as an indication of the aquatic existence which the river could have under ideal conditions. The "character" of this section was used for comparison with that of the lower section.

The second section begins at the town of Canton and ends at

Walters Lake. The Champion Paper Company is located in Canton, North Carolina, and is the major source of chemical pollution of the Pigeon River. It has been documented that before the Champion plant put water pollution abatement equipment into operation, circa 1962, the river was a "dead river." Until 1970, the year during which secondary water treatment equipment was placed in operation, there were periods when, because of very low dissolved oxygen and large pH fluctuations, no life other than bacteria could have existed in the water. After the installation of this equipment, the river was left to recover from its dead state. It was assumed that it had recovered, since there were reports of fish some distance below the present effluent, but no documented evidence of this recovery existed. Thus, it was our goal to establish characteristics of the river at this point in its history.

Sampling at the various sites below the town of Canton enabled us to postulate the characteristics *versus* kilometer flow. The sampling of streams and creeks feeding the system was conducted for indications of possible life sources. The following chemical tests were conducted at various times during the sampling period or were monitored on a steady basis: acidity, alkalinity, ammonia, chemical oxygen demand, chloride, dissolved oxygen, residual chlorine, lignins, nitrates, phosphate (total and ortho), pH, settlable solids, sulfate, sulfide, temperature and turbidity. These values were significant to the river's characteristics, arising from the paper plant effluent, and serving as back-up information for the biological data. The biological tests concentrated mainly on species identification, species diversity, and the effects of pollution in relation to the microenvironment.

Our group has shown that fish have moved into the waters below the effluent. Over 30 species were found in the 30-mile sampling area. The species diversity is high for fish and macroinvertebrates above Canton, then both decline at the effluent, and then climb with distance. There were two slight momentary drops in this climb, both of which were accounted for. At the last sampled station, species diversity had not attained the level of the upstream area. The microbiological study showed very low colony counts upstream, a rise at Canton, and the highest values below the Waynesville community. The majority of the chemical tests had their highest values at Canton and lowest values on the east fork of the Pigeon River. In a number of cases, a second increase (but one with values less than those at Canton) was found below the Waynesville community.

The fish and macroinvertebrate studies jointly indicate that the recovery of the river has stopped and, under present conditions, is "stuck" in a state of radical contrast to its nonpolluted counterpart.

The first factor for future recovery is the expedient installation of a secondary treatment facility for the Waynesville sewage treatment plant. It is our understanding that this part of the plant is in the bidding stage.

The second area for improvement is the most important, yet most difficult to accomplish. The pollution abatement equipment at the Champion Paper plant complies with, and often exceeds, Federal regulations and standards; however, such nonregulated pollutants as color, temperature, and turbidity are at levels intolerable for life to exist at prepollution conditions. These three factors (temperature, color and turbidity) together will prevent any future recovery and are, therefore, the major disrupting factors in the water system. These two areas of improvement will be of the greatest benefit for any future recovery of the water system to its non-polluted state.

Reference copy: Library of the University of North Carolina at Asheville

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A Comprehensive Ecological Study of Lake Shetek, A Model Lake

(Grant no. GY-10778)

Southwest Minnesota State College
Marshall, Minnesota 56258

June 6, 1973 - August 17, 1973

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Lake Shetek, one of the largest lakes in southwestern Minnesota, offers one of the finest outdoor recreational facilities in the region. Because of its shallow nature and heavy recreational use, Lake Shetek is highly susceptible to pollution, as evidenced by the extent of eutrophication.

The intent of this project was to evaluate water quality, determine specific sources of pollution, and suggest possible methods for lake improvement. To achieve these objectives, an interdisciplinary approach was adopted. Three areas of study were selected: (1) Water quality survey, (2) Geological survey, (3) Pesticide analysis survey.

Water samples were collected and analyzed on a weekly basis from 52 representative sites in the lake proper and in the surrounding watershed region. In addition to this sampling program, two other categories of water samples were collected and analyzed. Tests were made on well water from farms and cabins adjacent to Lake Shetek and on water collected in areas where actual or potential pollution problems were observed.

Samples were analyzed for the following biological, chemical, and physical parameters. (Methods used in the various analyses paralleled procedures outlined in Standard Methods for the Examination of Water and Wastewater, 12th Edition, 1965.)

I. Biological

1. Total Coliform
2. Fecal Coliform
3. Enteric Pathogens

II. Chemical

1. Nitrate, Nitrogen
2. Orthophosphate
3. Hardness
4. Alkalinity
5. Carbon Dioxide
6. Dissolved Oxygen
7. Biochemical Oxygen Demand
8. Ammonia, Nitrogen
9. pH

III. Physical

1. Temperature
2. Turbidity
3. Transparency
4. Color
5. Dissolved Solids
6. Suspended Solids
7. Total Solids

An examination of the biological data indicates that the coliform values were excessively high at several of the sample sites. Fifteen percent of the regular sample sites exhibited average total coliform levels in excess of 10,000 MPN/100 ml, indicative of heavy pollution that definitely poses a serious public health problem. Forty-four percent of the regular sample sites had coliform levels greater than 1000 MPN/100 ml, which is the maximum level allowable for swimming purposes. All public swimming areas were within acceptable coliform levels; however, several private swimming areas exceeded recommended levels.

Coliform levels were shown to be high at various points in the lake, with levels in the lower lake being significantly above those in the upper lake. High values in the lower lake were due primarily to water entering by three inlet streams.

Data from sample sites 13, 20, and 25 show average coliform counts of 75,073 MPN/100 ml, 39,260 MPN/100 ml, and 71,499 MPN/100 ml, respectively. Coliform values in these three inlets were highest during the spring runoff period and after periods of heavy rainfall. Two sources of observed coliform organisms were runoff from animal wastes associated with agricultural activities and from sewage and septic systems discharging into inlet waters.

Coliform values in the upper lake were attributed to the major inlet, which enters the lake on the northeast shore and serves as a principal source of water. The average total coliform level at Site 1 in the inlet was 7,329 MPN/100 ml. Several cattle-raising operations in this region contributed to the observed values.

In regions of the lake having an extensive lake shore development, increases in coliform were observed; however, these increases were generally small in magnitude and the exact sources of the contamination were not identified.

Sites exhibiting high total coliform levels were analyzed for fecal coliform group organisms and for the presence of potential pathogens. Pathogenic organisms, including members of the Salmonella group, were isolated from several sample sites, primarily in the inlet regions.

The levels of orthophosphate were high at all sites tested. As was the case with coliform levels, the amount of phosphate observed was significantly higher in the lower lake. Values obtained in the lower lake ranged between 0.5 to 0.8 ppm, whereas upper lake values were generally between 0.3 to 0.4 ppm. This difference was due to the high amounts of phosphate in the three inlets entering the lower lake. The primary source of the observed phosphate would appear to be from fecal waste contamination, since a close correlation between coliform and phosphate levels was detected.

Nitrate, nitrogen levels were also high, although more variable than the orthophosphate levels. Nitrate levels within the lake itself generally ranged between 0.5 to 7.4 ppm, with several sites exceeding 2.0 ppm nitrate, nitrogen. High levels of nitrate, nitrogen were caused by tile and drainage systems discharging into inlet waters.

The levels of nitrate, nitrogen and orthophosphate resulted in the excessive growth of blue-green algae. The presence of algae was reflected in the elevation of turbidity and suspended solids values as the summer progressed. In addition to being undesirable esthetically and in enhancing sedimentation problems, the heavy growth of algae will probably lead to serious fish kills in the coming winter months.

Recommendations for improvement of water quality conditions in Lake Shetek are being investigated with the appropriate local, State, and Federal agencies. Recommendations and suggestions include: elimination of runoff contamination in inlets and in the lake proper, construction of feedlot waste holding systems, establishment of nutrient trap areas on the lake inlets, establishment of green belts along inlets and along lakeshore, and the restriction of direct cattle access to the lake and inlet waters.

The intent of the geological survey was to investigate the current geological conditions in and around Lake Shetek. Efforts were concentrated in two areas: (1) construction of a topographic map of the lake bottom; (2) resistivity mapping of ground water channels in the lake region.

The construction of the contour map of the lake bottom was accomplished by a plane table triangulation technique. Approximately 640 data points were used in constructing maps of the lake bottom. The total surface area of the upper and lower portions of the lake are 1,560 acres and 1,500 acres, respectively.

The contour maps indicate that approximately 40% of the lake has a depth of 6 feet or less, with the remaining 60% between 6 to 10 feet. The deepest part of the lake was observed in the center of the upper lake where on 11-foot depth was recorded.

Ground water mapping was accomplished by means of electrical resisitivity measurements. This technique enables one to identify sand and gravel layers, which are the principle routes for underground water flow. Results indicated that Lake Shetek is located in the center of a major ground water channel running northwest to southeast. Sand and gravel deposits are especially predominant near the lake outlet, which may allow a substantial underground flow of lake water. Although the significance and extent of underground flow in Lake Shetek is difficult to evaluate at present, information concerning the location of these deposits is of great importance to future residential and commercial development, because of potential pollution problems associated with underground water flow.

The pesticide analysis laboratory was established to analyze water samples for the following chlorinated pesticides:

1. Aldrin
2. DDD
3. o,p-DDT
4. p,p-DDT
5. Dieldrin
6. Heptachlor epoxide
7. Kelthane
8. Lindane
9. Methoxychlor

Procedures for analyses were adopted from methods outlined by the Environmental Protection Agency. Electron capture gas chromatography and thin layer chromatography techniques were used to confirm the presence of specific pesticides.

Fifty different sites within Lake Shetek were analyzed for the presence of pesticides. Findings indicate that 10% of the sites sampled contained confirmable amounts of chlorinated pesticides.

The most frequently observed pesticide was DDT, found at four of the sample sites. Detectable concentrations of DDT were observed at two sites in the upper lake along the northwest shore. The highest concentrations of DDT were found in the lower lake at Site F (1.1 ppb) near Lake Shetek State Park, and Site 18 (.8 ppb) at the Public Access near the southwest corner of the lake.

The water samples in this study were found to be relatively free of chlorinated pesticides. However, this does not negate the possibility that significant concentrations of chlorinated pesticides exist in fish, aquatic organisms, and bottom sediments.

Reference copy: Southwest Minnesota State College Library

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Impact of Argo Tunnel Acid Mine Drainage and Mine Tailings and Abatement Procedures (Grant no. GY-10798)

Colorado School of Mines
Golden, Colorado 80401

June 25, 1973 - August 31, 1973

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The purposes of this study were to evaluate the impact of the Argo tunnel acid mine drainage and the associated mine tailings on the water quality of Clear Creek and to experiment with possible abatement procedures. The study area is located in Idaho Springs, Colorado.

All chemical analyses, except Na, As, Se and Cr, were performed on a Perkin-Elmer 303 Atomic Absorption Spectrophotometer. Sodium was determined by a flame photometric method, and As, Se, and Cr were analyzed colorimetrically.

The Argo tunnel drains about 27 abandoned mines in the Central City-Idaho Springs Mining district at an average flow of 1.2 cfs. The following average concentrations were detected over the summer of 1973 in the Argo drainage: Fe, 340 ppm; Mn, 160 ppm; Zn, 75 ppm; Cu, 13 ppm; Pb, 110 ppb; Cd, 320 ppb; As, 420 ppb; SO_4, 2700 ppm; pH, 2.7.

The impact study was first approached by performing a laboratory study of pH dependence on heavy metal behavior, and interactions of heavy metals. The study indicated that Argo's major heavy metals precipitate in the following order: Fe (pH 2.5-4), Cu (pH 4-6), Zn and Cd (pH 5-7.5), and Mn (pH 6.2-8). It was also determined that Fe, and to a lesser extent, Mn, could cause Zn and Cd, and especially Cu, to precipitate at lower pHs than in the absence of Fe or Mn.

The surface waters of Clear Creek in the Argo area were twice extensively sampled, using a grid system of sample locations, and weekly monitoring of Clear Creek was conducted at 6 sites during the summer. The first grid sampling took place at a creek flow of 850 cfs and a flow in the Argo drainage of about 1.2 cfs. The input of heavy metals from the Argo drainage roughly doubled the amount of total Fe, dissolved Mn, and dissolved Zn in Clear Creek. Concentrations of total Fe and dissolved Mn were in excess of the USPHS drinking water standards downstream from the Argo drainage. During the second grid sampling, the Clear Creek flow had decreased to about 225 cfs, while the Argo flow remained roughly constant, resulting in a greatly increased effect on Clear Creek. An examination of flow data indicated that, during 60% of the year, the flow of Clear Creek at Idaho Springs is less than 100 cfs, and 40% of the time, less than 50 cfs. The impact of the Argo drainage on Clear Creek, at these lower flows, is projected to rise exponentially, giving rise to the following expected total concentrations in the stream during 40% of the year: Fe > 7 ppm; Mn > 3 ppm; Zn > 2 ppm; Cu > 300 ppb, Cd > 10 ppb, and As > 10 ppb.

Weekly monitoring of Clear Creek gave indications that the concentrations of heavy metals in the Argo drainage tend to decrease during the time of low flow in Clear Creek. The heavy metal concentrations in the creek upstream from the Argo drainage tended to rise during lower flow, counterbalancing the decreased concentrations in the Argo drainage, to some degree. Monitoring of Clear Creek also showed the increased impact of the Argo drainage at lower flow.

The interaction of the stream and the coatings on the rocks in the stream bed was investigated. The coatings were found to be composed primarily of Fe, which rapidly precipitates as Argo water enters the creek. Also, large amounts of Pb and As, which are present in low concentrations in the Argo drainage, were detected in the rock coatings. Cu was also found in large quantities in the rock coatings, but Mn and Zn were notably depleted in the rock coatings near the Argo drainage. Trends were seen in the composition of the bottom sediments with distance from the Argo drainage and thus in the pH, which are in agreement with what would be expected from the laboratory study of heavy metal behavior.

Due to technical problems, subsurface and rainwater samples were not obtained directly, so two model tailings piles were constructed, one with mine and one with mill tailings. Samples of rainwater running over and through these piles were collected and analyzed. The mill tailings waters generally showed greater concentrations of heavy metals than the mine tailings water. The mine tailings do not usually appear to be a large source of heavy metals flowing into the creek. During heavy rains, however, heavy metals from the tailings may be highly deleterious to the water quality of Clear Creek.

Bacteriological studies included the monitoring of Clear Creek and its tributaries, and attempting to determine the effect of pH, Cu^{+2}, Zn^{+2}, Fe^{+2}, and Mn^{+2} on Escherichia coli. The Argo drainage lowered the bacterial count in Clear Creek for a short distance, but no permanent effect was noted. The idea that the Argo drainage might have the effect of counteracting human wastes emptied into the stream is not plausible in light of our results. The effects of pH, Cu^{+2}, Zn^{+2}, Fe^{+2}, and Mn^{+2} on E. coli were inconclusive.

The second phase of the project included experimenting with possible abatement procedures. Soda ash, lime, limestone and fly ash were investigated as neutralizing agents. All, except limestone, were found to be effective. The large amounts of fly ash necessary (10 wt. percent) eliminated it as a practical neutralizing agent. About half as much lime (1.05 gm/liter) as soda ash was necessary to neutralize Argo water to pH 9. The reaction rates of soda ash and lime with Argo water were similar. Since lime costs less than half as much as soda ash, lime was investigated further. It was determined that if Cu and Zn could be recovered and sold as by-products of neutralization, it may be profitable to neutralize Argo water. Manganese also has economic potential if recovered in relatively pure form. Further investigation of profitably neutralizing Argo water is strongly urged.

Proteinaceous substances (wool, chicken feathers, and human hair) were examined as heavy metal scavengers and found to be ineffective.

Reference copy: Arthur Lake Library, Colorado School of Mines

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Water Quality of the Upper Iowa River Watershed (Grant no. GY-10742)

Luther College
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May 23, 1973 - August 16, 1973

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Thirty sites in the Upper Iowa River watershed were sampled periodically; measurements were made of water chemistry, coliform bacteria, land use, and fish, macroinvertebrate, and algal populations. Most of the sampling sites were located in five sub-basins: Canoe, Ten Mile, Bear, French, and Silver Creeks. In addition, sites on the Upper Iowa River, above and below creamery effluent, and above and below the Decorah sewage treatment plant effluent were sampled, as well as sites above and below the Upper Iowa's entry into the Mississippi River.

The land use survey indicates that Canoe and Ten Mile Creeks have more cultivated cropland than Silver and French Creeks. Sixty percent of the Canoe and Ten Mile Creek basins was cultivated cropland, while 38% of the Silver and French Creek basins was in crops. Canoe and Ten Mile Creek basins contained more level land, suitable for farming, than French and Silver Creeks. Fifty-four percent of the land in Silver and French Creeks was devoted to pasture, while 29% of Ten Mile and Canoe Creek land was in pasture. These differences in land use affect the water quality of the sub-basins, as shown below.

Chemical analyses included alkalinity, ammonia-nitrogen, carbon dioxide, chemical oxygen demand, chloride, dissolved oxygen, nitrate-nitrogen, nitrite-nitrogen, orthophosphate, pH, specific conductance, filterable and nonfilterable solids, sulfate, water temperature, and turbidity. Dissolved oxygen levels dropped noticeably in the lower portion of the river, where the stream bed has been straightened and channelized. Phosphate levels were elevated in the channelized portion of the river. Dissolved oxygen levels were higher in French, Silver, and Canoe Creeks than in Ten Mile and Bear Creeks. All dissolved oxygen levels in the basin were well above the four mg/l minimum for fish populations. Nitrate-nitrogen and orthophosphate levels were lower in Silver and French Creeks than in Ten Mile, Bear, and Canoe Creeks. These values may be due to the more limited use of fertilizers and the lesser amount of cultivated cropland in the Silver and French basins.

Coliform bacteria analysis was made using membrane filter technique and differential plating for total coliforms, fecal coliforms, and fecal streptococci. Geildreich has stated that fecal coliforms should not exceed 200 counts per 100 ml for primary contact recreational water. Fecal coliform counts ranged from the unusual low of 376 per 100 ml in the upper regions of the Upper Iowa to 13,600 near the mouth. Common fecal coliform levels were in the 900-2000 counts per 100 ml range. Total coliforms were an order of magnitude higher in the more heavily-farmed basin of Canoe Creek than in Silver and French Creeks. Fecal coliform/fecal streptococci ratios of greater than four have been used to indicate human waste. The only FC/FS ratio over four was a value of 4.2 found just below the Decorah waste treatment effluent. High coliform counts in the rest of the river basin could be attributed to a combination of human and animal waste.

Sixty-three genera of algae, representing six orders, were found throughout the river basin. There were eleven genera in the phylum Chrysophyta found at nearly every site. Five genera of Chlorophyta and two genera of Cyanophyta were also very widespread.

The most common orders of the 113 types (genus or family) of macroinvertebrates found in the basin were Ephemeroptera, Trichoptera, Coleoptera, and Diptera. Simuliidae, Chironomidae, Baetis, Stenonema, Cheumatopsyche, and Hydropsyche were present at nearly every site.

The two main families to which the fish specimens belonged were Percidae and Cyprinidae. The more common fish found were the Central Johnny Darter, Striped Fantail Darter, Northern Common Shiner, Long-nosed Dace, and Black-nosed Dace.

Inferences about macroinvertebrate, phytoplankton, periphyton, and fish populations were made using cluster analysis and total mean diversity. Dendograms of cluster analysis, which were constructed using Jaccard coefficients of association, showed similarities within the Silver and French Creek basins for macroinvertebrates, phytoplankton, and periphyton. The mean diversity index for macroinvertebrates increased slightly with increasing stream order.

Reference copy: Luther College Library

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The Water Quality of the Souris River Basin, North Dakota

(Grant no. GY-10770)

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June 4, 1973 - August 24, 1973

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Thirty-seven sites along the United States' portion of the Souris River Basin were sampled over an 11-week period. Thirty-four of these sites were visited on a weekly basis and three visited biweekly for a 24-hour interval. All water used for analysis was obtained as grab samples taken below the water surface. Field analyses included air and water temperatures, total alkalinity, phenolphthalein alkalinity or acidity, pH, and sulfite. The other analyses, dissolved oxygen, nitrate, nitrite, orthophosphate, total phosphate, sulfate, chloride, Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), total dissolved solids, conductivity, fecal and total coliform counts, chlorophyll content, several metal ion concentrations, and pesticide extractions, were performed in the laboratory. Procedures for total alkalinity, phenolphthalein alkalinity and acidity, sulfite, dissolved oxygen, sulfate, chloride, total dissolved solids, and fecal and total coliform count were taken from Standard Methods for the Examination of Water and

Wastes. Pesticide extraction procedures came from the North Dakota State Laboratory who agreed to run the extractions on their equipment. BOD and conductivity were measured using Hach instrumentation. Chlorophyll procedures were taken from recent literature on productivity. Procedures for ortho- and total phosphates, nitrate and nitrite were taken from EPA's Methods for Chemical Analysis of Water and Wastes. Metal concentrations were determined using Atomic Absorption Spectroscopy. Information was punched on cards and transferred to a disk, using an 1130 IBM computing system.

Monthly averages indicated water quality violations for total dissolved solids and sulfates over wide reaches of the river, as well as some dissolved oxygen and bacteria deficits. Some metal concentrations were also in violation of Federal water quality standards.

Weekly samples and monthly averages showed distinct patterns of concentration, indicating the possible value of the shallow wildlife refuge impoundments as settling points for inorganic nutrients.

Sulfate and total dissolved solids were much higher than values reported by a 1969 water quality survey. This earlier survey, taken during above normal streamflow conditions, suggested that higher sulfate and total dissolved solids would be encountered in low streamflow conditions. Nitrate and phosphate levels were nearly the same.

Calcium, magnesium, and sodium are the predominant metals in the water system, but the system also has high iron and manganese concentrations. Strontium, zinc, copper, lead, mercury, and cadium were also detected.

As the summer progressed, several of the shallow refuge impoundments became the sites of intense algal blooms. Algae identified in the blooms included aphanizomenon, microcystis, and anabena. Bloom areas had high BODs. During early stages of the blooms, oxygen levels were high but, as the blooms progressed, oxygen levels fell off to less than two milligrams per liter. Water flowing out of the bloom areas also exhibited low dissolved oxygen levels.

The primary use of the river system now is waterfowl production. The water quality is adequate for this use. The Souris River also serves for recreational activities, as a municipal water supply, and as an irrigation water source. The Souris River is an adequate irrigation source, but some water quality parameters are approaching threshhold limits. In low flow periods, use as a water supply or for recreation must be considered marginal. Algal blooms and high iron and manganese levels cause odor and taste problems. High sulfate levels also impart an undesirable taste and can produce a laxative effect.

The importance of having basic water quality information increases as plans for water development in the area are made. Three projects are currently planned for this area. These include the channelization of the Souris River through the city of Minot, construction of a dam at Burlington, North Dakota (for flood control for the city of Minot), and the Garrison Diversion irrigation project. Prior to this investigation, the only information on the river was the study done in 1969 and U.S. Geological Survey tests made once a month at six points throughout the basin.

Reference copy: Memorial Library, Minot State College

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The Chemical Basis of Interaction between Aquatic Bacteria and Phytoplankton (Grant no. GY-10796)

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May 28, 1973 - August 17, 1973

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The objectives of this study were to culture aquatic bacteria, to isolate organic products produced by the bacteria, to characterize their effects on an algal system, and to assay the pure compounds on algal systems, if possible.

The problem was approached through the isolation of 14 strains of bacteria from Lake Michigan waters. These bacteria were characterized as 5 strains of Pseudomonas, 2 strains of Xanthomonas, 2 strains of *Flavobacterium*, 3 strains of *Achromobacter*, 1 strain of the yeast, *Rhodotorula*, and 1 strain of an unidentified white filamentous mold forming subsurface colonies and black spores.

The organisms were grown in mass culture, and separated from the spent media by filtration. The medium was subject to solvent extraction after lyophilization, spot testing, and thin-layer chromatography of positive fractions. Gas chromatographic analysis revealed no significant compounds in the non-polar solvents used.

The thin-layer chromatography of unlabeled media revealed no compounds not present in the control fraction; thus, it was suspected that amino acids were being produced. Cultures were grown in the presence of C-14 labeled glucose and then subjected to thin-layer chromatography. Proline was detected in one strain of *Xanthomonas*, and four other amino acids were identified as possible compounds: arginine, aspartic acid, serine and threonine.

The medium was also concentrated by rotary evaporation and subjected to gel filtration through Sephadex G-15. Most bacteria exhibited bioassay activity. Bioassays were conducted on unialgal cultures of *Asterionella formosa* and axenic cultures of *Synedra delicatissema* var. *anguastissima*, two diatoms from Lake Michigan. The technique used was the $HC^{14}O_3$ assay of photosynthesis.

In general, *Asterionella* appeared to be more capable of stimulation than *Synedra*, as reflected in the comparision between runs of the same fractions. Some bacterial fractions exhibited activity (predominantly inhibition) in the void volumes (molecular weight greater than the gel exclusion limit, 1500 daltons). In other bacteria, peaks of inhibition or stimulation were noted at varying elution volumes. pH is ruled out as a causal agent, since fractions were eluted with 3 millimolar Bicine-HCl buffer at pH 7.8.

A bioassay was made, using Asterionella and l-alpha-proline, a suspect agent, to concentrations as low as 16 micrograms/liter. It was determined that proline concentrations less than 1.67 g/l effected highly significant stimulation (up to 150%) of photosynthesis.

It is suggested that further studies of three types be undertaken in this area. The first would be additional bioassays of suspect compounds, particularly, the amino acids. The second would include additional searches, using methodology developed here (especially radiochromatography), to elicit further classes of compounds that may have possible algal activity, especially higher molecular weight substances. The third type of study would be to determine what environmental conditions would affect the production of algal-active agents by bacteria.

Reference copy: Department of Chemistry, Illinois Institute of Technology

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Pollution Studies of the Cuyahoga, Chagrin, and Grand Rivers Using Non-Dispersive X-Ray Fluorescence Spectroscopy (Grant no. GY-10745)

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This project used non-dispersive x-ray fluorescence spectroscopy (XFS) to monitor the Cuyahoga, Chagrin, and Grand Rivers, their tributaries, and municipal water supplies in the area. The technique is useful for determining the composition of substances in concentrations as low as parts per million or less for all elements heavier than sodium.

The goals of this project were: 1) to determine the elemental composition of foreign matter in the water at several locations in the Three Rivers area, and to monitor changes in composition comprehensively from June to August; 2) to identify the sources of these elements (natural mineral deposits, agricultural activities, industrial pollution, etc.); 3) to examine the water for potentially hazardous concentrations of toxic elements (mercury, cadmium, lead, arsenic, selenium, etc.).

Non-dispersive X-ray Fluorescence Spectroscopy

When any material is irradiated with "white" or continuous x-rays having a range of energies from one to 20KEv. (12 to .5A), the material will absorb some of this radiation and re-radiate it. This re-radiated energy, or fluorescence, occurs at only distinct energies or wavelengths corresponding to energy levels present in the atoms. In the x-ray energy range, most electrons have only one or two transitions or energy levels, so the fluorescence spectrum produced by a material of even several elements will be fairly simple. With the proper detector and electronic equipment, each element's fluorescence will be indicated as a "peak" on a graph or display. The energy location of the peak identifies the element which produced it, and the height of the peak (the intensity of the fluorescent radiation) determines the concentration of the element present.

The group developed a complete x-ray fluorescence spectrometer system during the course of the project. The spectrometer can handle up to 20 samples at a time, completely automatically. The spectrometer can detect and measure the concentration of the elements present in a one-liter water sample at a sensitivity of 100 parts per billion (.1 milligrams/liter) for all elements from uranium to calcium in just eight minutes. Determinations can be made down to silicon at reduced sensitivity, and the sensitivity for all elements can be improved by a longer running time.

Procedure

The group used x-ray fluorescence spectroscopy, atomic absorption spectroscopy (for light elements), and some supplementary measurements in the laboratory and in the field, such as dissolved oxygen, turbidity, temperature, conductivity, and pH, to study the water of the area. All municipal water supplies were sampled twice, in June and in August. Comprehensive sampling of the three major rivers was carried out monthly during June, July, and August. Some special studies of particularly interesting areas and of the rocks and till of the area were carried out.

Findings

XFS - The group developed x-ray fluorescence spectroscopy as a powerful analytical tool for water quality control. No other technique can detect so many elements in so short a time. In addition, the ability to automate the analysis provides a very large sample throughout, since analysis can be done easily on a 24-hour a day basis.

Municipal Supplies - Although there were many cases of municipal water supplies being slightly below the recommended quality standards for one or two categories, no serious health hazards were discovered for city water supplies. Some private wells in smaller communities may, in fact, be serious health hazards. This group includes wells in Chesterland (1.9 grams dissolved solids), Boston Heights (2.1 grams dissolved solids), Thompson (1.7 grams dissolved solids, 5ppm Zn), and others.

A large-scale implementation of XFS by State agencies could provide an annual analysis of private wells at a cost of a few cents. This analysis would be valuable in locating mineral deposits, as well as in determining potential health hazards.

Rivers

Most of the elements present in the river system of this area can be attributed to the natural rock and till of the area. Some large concentrations of zinc were found early in the summer in several areas. This finding was probably due to agricultural activities, since several insecticides popular in this area contain huge amounts of zinc. Other exceptions to the natural elemental composition of the rivers are noted in the commentary on each river section below.

Grand River -

A) North-South Section - flows through agricultural area. Has moderate amounts of Cl, Cr, small amounts of Na, Mg, K, and trace amounts of Ti, Mn, Fe, Cu, Zn, Br, and Sr. B) East-West Section - shows generally lower concentrations of everything found in A, even though tributaries are from populated areas. This can be attributed to the geologic changes from the North-South section. C) The river in Painesville becomes highly polluted from industrial activities. Total dissolved matter averaged 6g/l last summer. On different dates Na, Cl, and Ca were found in excess of 1000 ppm!

Chagrin River -

D) The Chagrin River runs through a lightly-populated suburban area. A large portion of the river frontage is part of the Cleveland Metropolitan Park. The river is generally the cleanest in the study area.

Cuyahoga River -

E) The upper Cuyahoga has higher elemental concentrations than does the North-South section of the Grand River even though it has the same geologic and geographic configurations. This may be due to the reservoirs on the river which allow a large water-to-rock interface. Near and in Akron, traces of As, Mo, Cr, and Cd have been found in the river. F) The "Little Cuyahoga" in Akron is generally two to three times as polluted as the main branch. G) Lower Cuyahoga from Akron to Cleveland - is in a heavy industrial area and is highly polluted.

Reference copy: Hiram College Library

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Analytical Aspects of Clams and their Habitat Relevant to Nutrition and Pollution (Grant no. GY-10779)

St. Mary's Dominican College
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May 28, 1973 - August 3, 1973

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The aim of this project was to determine the nutritional value of Rangia cuneata clams as an indication of its value to possible consumers, and to ascertain the types of pollutants in

Lake Pontchartrain clam-bed areas. The opening of the Bonnet Carre Spillway prior to the start of our project provided us with an added interest, for during the course of the project the spillway was closed and we were able to observe the resultant changes.

To determine the nutritional value of *Rangia cuneata*, the percent protein and the amino acid constituents were assayed. The classic Kjeldahl procedure was used for the protein analysis. Three determinations were made for each collection of clams; these results were averaged and recorded. Ascending chromatography, using a saturated phenolic solvent, descending chromatography, employing a butanol-acetic acid-water solvent, and thin layer chromatography, using a cellulose acetate support media, were utilized to identify the amino acid constituents of clam meat. Known standards of amino acids were run with each unknown set, and the Rf (distance from the start of the solvent to the mid-point of each spot, divided by the distance of the solvent front) of each spot calculated. Comparison of the known standard Rfs to the unknown spots enabled us to arrive at our conclusions. Furthermore,a nutritional study, involving 15 ACI/Tex male rats divided into five different experimental diet groups, was performed.

To ascertain the pollutants in Lake Ponchartrain and surrounding waterways, various chemical and bacteriological studies were made. Included in the chemical analysis were water studies, utilizing the LaMotte test kits (Model AM-22, Water Pollution

Outfit) and standard laboratory tests, pesticide assay (following the procedures outlined in the Pesticide Analytical Manual of the U. S. Department of Health, Education and Welfare), and trace metal analysis of clam and soil samples by atomic absorption spectroscopy using a Varian Techtron AA-5. Bacterial analysis was undertaken in accordance with Standard Methods.

Sediment analysis is an important aspect of the study of the habitat of Rangia cuneata since these animals are filter feeders which nourish themselves while resting on the bottom of the waterways. In analyzing sediment, three chemical parameters were investigated, i.e., pH, percent organic matter, and percent silica.

Sampling was done in Lake Ponchartrain primarily, with some sampling also in Lake Maurepas and Lake Borgne. While collecting clams, water and sediment samples were obtained in polyethylene bottles and returned to the laboratory for analysis.

Data were collected at the end of each sampling period and processed prior to the second collection from that series of locales. This allowed sufficient time to calculate and record results that could then be used for comparison with the second set of values from that locale. Each site was sampled at two-week intervals for a total of three collections. Only one determination for pesticide and trace metal analysis was conducted because of the lengthy nature of these procedures.

Rangia cuneata clams contain a relatively high percentage of protein (22.0%, dry basis) and a great many of the essential amino acids such as leucine, lysine, methionine, phenlyalanine, threonine, tryptophan and valine. Rats fed the clam diet showed a sufficient but not optimal growth when compared with control rats. The average weight gain for each group of rats was as follows: The casein-fed rats gained 13 g; the smaller rats fed clams gained 30.3 g; the rats fed clams plus estimated missing amino acids gained 26.3 g; the control rats fed food pellets gained 46.3 g; and the larger rats fed clams gained 14.5 g.

Evaluation of our water analyses was carried out in correlation with random values obtained from the U. S. Corps of Engineers. Thus, we were able to follow the changes in Lake Ponchartrain subsequent to the closure of the Bonnet Carre Spillway by comparing our data to information on the lake obtained prior to the opening of the spillway. The chloride concentration, initially quite low because of the presence of low-salinity Mississippi River water, rose significantly over the test period. To cite one example, the chloride rose from 68 ppm to 755 ppm from June 4th to July 16th for L-5. Ammonia-nitrogen, nitrate-nitrogen, and alkalinity, which were initially high in comparison with data for the normal lake status, dropped, as did the total suspended solids.

With respect to pesticide, trace metal and bacterial analyses, general conclusions are difficult because of the wide range of values obtained. The heaviest pesticide contamination was noted at C-5 (the Tchefuncta River) where Dieldrin, Arochlor 1254, Chlordane, DDE, and DDD were found; no detectable pesticides were noted at C-4 (the Tangipahoa River) and C-7 (Lake Borgne, southeast). Aluminum and iron were heavy soil contaminants with values from 21650 to 68440 ppm for aluminum and 5220 to 31000 ppm for iron. Mercury was found to be present in concentrations ranging from 133 to 1590 ppm. Zinc, iron, copper and aluminum were present in the clam and oyster samples in fairly high concentrations. The estimated MPN of coliform covered a wide range. In general, the count seemed to increase from the group B series to the group C for water and sediment analyses, but to decrease for meat analysis.

Sediment analysis revealed that, in general, the clam-bed areas contained a low percentage of organic matter, from 0.57% to 17.77%, with one location being 30.67%; the percentage of silica was high, from 67.09% to 99.35%.

Reference copy: The John XXIII Memorial Library, St. Mary's Dominican College

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Evaluation of Algal Productivity in Green Lake, Wisconsin with Bioassay Techniques (Grant no. GY-10749)

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May 21, 1973 - August 10, 1973

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Green Lake, the deepest lake in Wisconsin (70 m), has experienced many signs of cultural eutrophication within the past ten years. The primary deleterious effect is the enhanced algal productivity and the subsequent sporadic algal blooms. A systematic survey of the biological, chemical, and physical lake parameters during the period from June 1, 1972 to May, 1973 established baseline water quality data. To assess the complex influence of the many individual factors on algal growth, a complex analysis was used. The Provisional Algal Assay Procedures (1969) and their subsequent modifications were utilized. The three fundamentally different test procedures were:

1) Bottle Test: Candidate test algae are added to the sample in the laboratory and growth is determined.
2) Continuous Flow Chemostat Test: Candidate test algae are added to a continuous-sample flow system. An attempt is made to keep the environment constant, and the objective is to develop a steady state of algal production. The test result is a growth rate.
3) In Situ Test: Part of the water body is isolated and incubated in place within a transparent container. The test result is an instantaneous growth rate for the confined portion of the body of water.

In addition, the phytoplankton population was qualitatively and quantitatively enumerated, using the membrane filter technique.

Physical and chemical measurements of gross water samples were also made, using Standard Methods. These selected techniques then allowed a determination of:

1) the levels to which nutrients in Green Lake must be reduced to limit growth to an acceptable level;
2) what the critical nutrients are that limit growth in Green Lake; and
3) what nutrients are available in the absence of algal toxicants.

Phytoplankton analysis showed green algae dominating the June collections, with blue-green algae replacing the green as the predominant form in the latter part of the summer. Cosmarium, Pediastrum, Scenedesmus, Staurastrum, and Fragilaria were present throughout the summer in relatively stable amounts. The blue-green algae, Anabaena, Aphanizomenon, and Gleotrichia, replaced the green algae in late July and early August. Blooms of Anabaena and Scenedesmus were noted in the twelve-week project period.

Bottle test results showed the response of the test alga, Selenastrum capricornutum (Printz) to variations in P and N species concentration. Inoculum from the Ripon Sewage Plants produced the greatest increase in algal biomass in all bottle bioassays (maximum standing crop = 461 mg/l). Silver Creek samples were third highest with 248.5 mg/l; and N,P, Fe spiked yielded 253.3 mg/l. N spikes of natural water samples produced increased biomass production (MSC = 161.55 mg/l), while P spikes did result in an appreciable increase (MSC = 10.8 mg/l). Micronutrients were shown not to be limiting for Green Lake algal growth.

Continuous culture (chemostat) data were not kinetically analyzed owing to insufficient runs at different hydraulic residence times. Visual inspection of the data does indicate a sustained high biomass production with Ripon Sewage Plant effluent and the low level response of lake water samples.

The *in-situ* carbon-14 uptake study demonstrated two distinctly different rates of productivity at two points on Green Lake. One meter measurements at Stations 6 (Quimby Cove) and 9 (Sliding Rocks) ranged from 0.890-.373 $mgC/m^3/hr$ and from 2.736-6.377 $mgC/m^3/hr$ respectively. The difference in rates was related to recent soil-disturbing/dredging operations in one area.

Statistical correlation analysis of all water chemistry and phytoplankton data collected indicated that PO_4-P and total N concentration increases/decreases occur simultaneously. A set of recommendations to control N and P input to Green Lake were prepared.

Reference copy: Lane Library, Ripon College

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Chemical Mass Balances in Estuaries (Grant no. GY-10771)

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June 4, 1973 - August 24, 1973

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The project proposed to study the chemical mass balances within estuarine systems by following the courses of various chemical species through the system and identifying their major sources and sinks. Silicates, organic carbon, nitrites, phosphates, major cations, and trace elements were analyzed in samples from different sections of the estuarine environment. The Merrimack River was the center of our efforts, with samples collected on eight different occasions over the summer and twice since that time. Also, three sets of samples were collected from the Parker Estuary, two from the Connecticut River Estuary, and one each from the Mousam, Kennebunk, Saco, and Royal Rivers in Maine. Sampling was done from a Boston Whaler stationed in the Merrimack and from a zodiac inflatable raft. Samples of water were usually taken from the surface, collected in plastic bottles for the determination of salinity, major cations, and silica, and in glass bottles stored on ice for determination of nutrients. Special samples are discussed when the data are presented.

The general method of interpreting each set of data was to compare it with its corresponding salinity data. If any processes occurring within the estuary are changing the concentration of certain species, then this change should be seen in a plot of the species concentration vs. salinity. If simple mixing between the river and ocean endmembers is occurring, the data should fall on a straight line between those endpoints. Otherwise, in the case of removal, the endmembers will be connected by a concave curve.

All of the major cations and chloride were found to be conservative as functions of salinity. Analyses were done by atomic adsorption spectroscopy.

Silicates, analyzed by a colorimetric technique, were, in nearly all cases, found to be conservative. One postulated mechanism of removal, uptake as a nutrient by diatoms, was tested by the determination of diatoms in the samples. In all cases, it was found that the diatom populations were too small to expect any visible removal (and, indeed, none was found).

Iron was analyzed and showed definite removal. Mechanisms are unclear, but a change in its oxidation state as it moves into seawater seems possible.

Sediment samples were collected and showed signs of the loss of trace elements, as the sediment was increasingly exposed to the marine environment. A simple equilibrium model is postulated.

Several biological samples were collected, including: organic carbon determinations; colorimetric determinations of phosphate and nitrite; and trace element analyses for plankton and blue mussel bodies. No conclusive results were obtained because of sampling and analysis difficulties and because of apparent complexities of the system.

There were many difficulties in modeling and sampling the estuarine system. A simple model to identify conservative processes is presented.

Reference copy: Lindgren Library, Massachusetts Institute of Technology

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A Study of the Biogeocoenosis of Two Merging Rivers, the Sheyenne River and the Red River of the North (Grant no. GY-10795)

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June 1, 1973 - August 24, 1973

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The goal of the project was to investigate, from an interdisciplinary prospective, the ecosystems of two merging rivers. The rivers were the Red River of the North and the Sheyenne River. Both are north-flowing rivers. The research team was divided into four chemists, four biologists and four bacteriologists.

The intent of the team was to both monitor pollutant levels, as well as monitoring ecosystem interrelationships. The following parameters were monitored: biochemical oxygen demand, dissolved oxygen, pH, nitrates, sulfates, mercury, trace metals, ammonia, phosphates, clarity, water temperature, total aerobic heterotrophic bacteria, fecal coliforms, Enterococci, Salmonella, Shigella, zooplankton, and phytoplankton.

Nine sample stations were used, five on the Red River and four on the Sheyenne River. Many random samples were also taken. Approximately 45-mile segments were covered on each river.

Procedures for the chemical analysis were taken primarily from those outlined in Standard Methods, but a new method for trace metals was used. It involved extraction from water samples by the use of a chelating agent, sodium diethyldithiocarbamate, in an organic phase iso-amyl alcohol. Phytoplankton isolation involved the use of settling chambers (an offshoot of a method derived by Lund and Evans). Diatoms were cleared for observation by incineration (Patrick and Reimer method) and by the use of concentrated nitric acid (new method). Zooplankton investigation of rotifers, crustacea and protozoans was accomplished by the concentration of water samples through filtration, followed by observation of a known quantity of aliquot. Bacterial studies followed

Standard Methods, but went much further. Intensive tests, as recommended by the U.S. Public Health Service, were run.

The standard for biochemical oxygen demand, as established by the U.S. Public Health Service, is 25mg/l. On the average, no sample stations exceeded this value during the research period. However, random sampling included the Fargo Sewage Treatment outfall. It was found to exceed 50mg/l. The State Health Department was notified and Fargo is presently undertaking plans for building tertiary treatment facilities. BOD maximums corresponded to total aerobic bacterial maximums. Nitrate maximums corresponded to total coliform maximums. It was found that the Fargo Sewage Treatment effluent was tremendously high in nitrates. Trace metals were at negligible levels, well within the Environmental Protection Agency's standards. The highest ammonia values existed north of the Fargo-Moorhead metropolitan area on the Red River. An inverse relationship was exhibited between nitrate and ammonia. Total bacterial aerobic counts ranged much lower in the Red River than in the Sheyenne River. A common occurrence was the increase of total aerobic counts after rainfall. All stations on the Sheyenne River consistently exceeded both State and Federal standards for total and fecal coliforms and some sites on the Red exceeded them, also. The fecal coliform/fecal streptococci ratio was useful in pinpointing sources of animal fecal contamination and human fecal contamination. The station nearest the Fargo Sewage outfall indicated human fecal contamination, whereas the stations nearest feedlots and near a North Dakota State Stockyards suggested animal fecal contamination. Partially as a result of these values, two feedlots will be forced to move back from the river bank; a permit allowing a stockyard effluent to be dumped into the river was revoked. Zooplankton analysis revealed that for every bacterial maximum there were Cladoceran maximums. (Cladocerans are filter feeders known to consume many bacteria.) Salmonella sp. was isolated from all stations and Shigella sp. was isolated from the sites north of the Fargo-Moorhead metropolitan area. Fifty-one different genera of phytoplankton were identified. The predominant genera were: Stephanodiscus, Melosira, Nitschia, Scenedesmus and Ankistrodesmus. These were found to be highly tolerant to large organic loads in water; both rivers have high organic loads. Average phytoplankton was found to be about four times higher in the Sheyenne than in the Red. Diatom species abundance was found to exhibit a shock reaction from the metropolitan area. New genera became dominant and dominant genera became insignificant, as water flowed through the Fargo-Moorhead metropolis. Zooplankton was found to be extremely high in the Red River and amazingly low in the Sheyenne. Zooplankton and phytoplankton in both rivers exhibited a numerical decrease as water flowed northward.

Reference copy: North Dakota State University Library

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Factors Governing the Dissolved Oxygen Content of the Waters of Dade County, Florida (Grant no. GY-10753)

University of Miami
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June 11, 1973 - August 20, 1973

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Dade County, Florida, presents a wide variety of problems in water quality management. To the West lies the freshwater Everglades, to the North, Lake Okeechobee, and to the East, the Atlantic Ocean. Since the early 1900's, canals have been constructed for drainage and flood control purposes from the Everglades and Lake Okeechobee towards the ocean. Many of these canals are periodically beset with problems of fish kills and clogging plant growth.

Two previous SOS studies at the University of Miami have dealt directly with fish kills, concentrating primarily on nutrient levels in the canals. This year a more biological approach to canal water quality, with more emphasis on local aquatic plant communities, was undertaken. Special emphasis was devoted to the introduced submergent aquatic plant, Hydrilla verticillata, to determine its growth rate under various conditions and its balance of photosynthesis and respiration. The unifying theme for the project was to be the construction of a dissolved oxygen budget in the canals.

Three diurnal samplings at each of eight representative Dade canal sites during the summer months provided data for the establishment of a typical dissolved oxygen curve for each site. No significant correlations were found between dissolved oxygen and any of the major dissolved nutrients, such as phosphate or nitrate. Similarly, correlations between BOD and chlorophyll content of the water with DO were not strongly established during the diurnal studies. This was due partly to the fact that both BOD and chlorophyll levels were lower than values previously reported. There was, however, an apparent inverse correlation between BOD and levels of coliform organisms.

Coliform bacteria were monitored at all sites during the overnight studies. This was done for two reasons. First, as an indication of water quality in relation to human standards, and second, as a method of tracing a pollution input to the canal systems. The latter phase also entailed the indicator of the fecal coliform to fecal streptococci ratio which may pinpoint human or nonhuman bacterial inputs. These analyses showed that the urban sites were often over the accepted safe swimming level of 1000 per 100 ml sample (MPN) and that most of these elevated coliform levels were primarily of human origin. There was also a strong positive correlation between rainfall and canal coliform levels indicating major stormwater runoff. It had been previously theorized that there may be correlations between coliforms and certain nutrients in the water, the two possibly having entered the system through similar means. This relationship was not established.

Biochemical oxygen demand levels were monitored during the diurnal samplings to determine losses from the dissolved oxygen budget for this source. Average levels were low, about 2-3 ppm. There were only slight differences between the urban and rural sites. Some doubt existed about the accuracy of the method used.

Surface water chlorophyll analyses showed interesting, though not surprising, trends. The range of values was from 2 to 84 mg per cubic meter, with an overall average at about 10 mg/m^3 for chlorophyll-a. Several instances of management efforts to control burgeoning plant growths were witnessed and are seen as the chief agents in preventing development of mature aquatic plant communities.

Growth rates of Hydrilla at most of the sites were measured by means of artificial planting experiments at varying depths. The average value obtained was about 8 mg per plant (dry weight) per day. Variations between sites seem to be attributable more to differences in transmittal of sunlight than to differences in any of the other parameters studied. Experiments to determine the growth rate of Hydrilla in the laboratory under defined nutrient conditions were largely unsuccessful because of poor experimental nutrient control and the difficulty of obtaining nutrient-starved cuttings for planting. An additional complication was the extremely low level of nutrients which Hydrilla seems to require for rapid growth.

Data for each of the subprojects were brought together in the description of the local canal dissolved oxygen budget. Although more work is required, procedures for maintenance of the most desirable aquatic environments are suggested.

Reference copy: Library, University of Miami

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Study of Mercury and Heavy Metal Pollutants in the Jordan Creek Drainage (Grant no. GY-10816)

University of Idaho
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May 21, 1973 - August 6, 1973

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From the 1860's to the 1930's, the Jordan creek drainage, which lies approximately 60 miles south of Boise, Idaho, was the location of a major gold and silver mining district. From the conclusions of a study by the Idaho Fish and Game Department on mercury contamination in fish, it is believed that this area was the source of mercury and other heavy metal deposits. These metals, particularly mercury, propose a potential threat to the human health and recreational resources of Owyhee and Antelope Reservoirs which lie on this creek.

A student team from the University of Idaho and Boise State College conducted an extensive study on the section of Jordan Creek which lies within the Silver City mining district. The team sought to locate the sources of mercury and other heavy metal deposits.

The group worked for 11 weeks during the summer of 1973, sampling plants, water, sediments, micro-invertebrates, fish and small terrestrial vertebrates, in an attempt to trace the mercury through the food chain. These samples were analyzed by atomic absorption spectrophotometry.

The results of this study provide valuable information on the sources and locations of mercury and other heavy metals in the Jordan Creek Drainage. They also show the concentrations of mercury in the game fish of the area, which is an immediate danger to man.
Reference copy: University of Idaho Library

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Toxic Chromium in Natural Waters - An Interdisciplinary Approach

(Grant no. GY-10763)

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June 11, 1973 - August 31, 1973

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Fundamental to the understanding of the behavior of Cr species in the aquatic environment is the possession and use of accurate analytical methodologies capable of selectively determining different Cr species when present at trace levels in the natural waters. Several such methods have been developed. Among them is a method for the preconcentration of sub-ppb to ppb levels of Cr(VI) from aqueous solutions. In this method, filtered water samples are acidified to pH 6, and passed through an anion-exchange resin bed (AG -1X4, 100-200 mesh, Cl- form) in an ascending flow so that the chromate is adsorbed in a narrow zone at the lower end of the resin bed. The elution is effected quickly by small volumes of acidic reductant solution which react with $CrO_4^=$ on the columns to form Cr(III) during the very elution step, thus producing very high concentration factors. When employing a Perkin-Elmer (P.E.) 303 flame A.A. (or any other similar A.A.), this method makes possible the determination of 0.5 ppb with a precision of ±20% or better.

In addition two differential analytical methods capable of distinguishing between different Cr species were developed. Of these two, Differential Method II was better. This method can be performed on a water sample as follows: 1) filter the sample, preferably through 0.45μ membrane filters; 2) adjust pH to 6; 3) divide water sample into three equal portions ≥ 1 liter each; 4) pass one portion through an anion exchange resin bed (AG - 1X4), and pass a second portion through a cation exchange resin bed (AG-50WX4); 5) the volumes of these two effluents as well as that of the third portion are reduced slowly by evaporation. Analysis of the remaining (~10 ml) volumes is then carried out. By algebraic manipulation, the amount of cationic (trivalent), anionic (hexavalent), and nonionic Cr present in the original sample can be determined. Using a P.E. 303 flame A.A., precision of ±20% for the Cr(III) and Cr(VI) analyses can be expected at levels of ≤ 0.5 ppb. The precision of the "nonionic" Cr analyses depends upon the precision of the Cr(III) and Cr(VI) analyses. Laboratory experiments carried with natural water samples and a radioactive Cr isotope indicated that a sample pH of ~ 6 was, indeed, called for when employing Differential Method II, and probably also when using other methodologies.

Using Differential Method II, analyses for Cr(III), and Cr(VI), and nonionic Cr were carried out on river water samples from the Upper Susquehanna River Basin. Almost all samples revealed low (0.5 - 2.0 ppb) concentrations of Cr(III), with generally lesser amounts of nonionic Cr. The concentration of Cr(VI) however, seemed much more site-dependent. As could be expected, the highest concentrations of Cr(VI) (≥ 2.5 ppb) were observed immediately below the sewage outfalls of the Triple Cities (Binghamton, Johnson City, Endicott). Samples taken from a site

80 km below the Triple Cities area revealed low concentrations of Cr(VI) (~ 0.1 ppb), typical of the samples taken upstream of the Triple Cities area.

Geologically-oriented investigations revealed that this decrease was due to the dilution brought about by a much increased discharge at this downstream site. An additional decrease in the Cr(VI) concentration at this downstream site could also have been brought about through the adsorption of Cr (at least originally present as Cr(VI)) on sediment particles, as the Cr content of sediment samples taken from the Susquehanna River directly downstream of the Triple Cities area contained considerably higher (≥ 130 ppm) Cr, when compared with samples taken from rivers upstream of the general Binghamton area (~ 30 ppm). (Sedimentation of sewage sludge particles high in Cr, however, could also account for the high Cr concentrations in the sediments taken from below the Triple Cities.)

Attempts at correlating the Cr speciation with such factors as D.O., B.O.D., etc. failed due to the relative constancy of these latter parameters vis à vis the fluctuations observed for the Cr(III), Cr(VI), and nonionic Cr concentrations in the waters analyzed.

Our attempts to correlate the Cr concentrations in algae with average river water concentrations were severely hampered because of the lack of availability of several of the same algal species, at the different river sampling sites. Practically no algae was found at the site down-stream from the Triple Cities sewage outfalls.

Laboratory studies on the uptake and toxicity of Cr(VI) to algae and duckweeds such as *Palmellococcus*, *Hydrodictyon*, *Oedogonium*, *Lemna*, and *Spirodela* indicate, however, that the Cr(VI) levels (~ 2.5 ppb) found at this site could not alone account for a lack of aquatic flora. (Synergisms with other pollutants are, of course, possible.) The high sediment concentrations of Cr, however, may well have discouraged the growth of such benthic algal forms.

The laboratory studies also revealed that when cultured in media relatively concentrated in Cr (10 ppm), algal (and to a lesser extent duckweed) species can exhibit very large Cr concentrations (> 1000 ppm). Although a distinction between *adsorbed* and *absorbed* Cr would have been very enlightening, time restrictions precluded such investigations. It is probable however, that a considerable fraction of these high Cr concentrations were present in an adsorbed state. A brief series of experiments indicated that dead *Hydrodictyon* cells are capable of removing very large amounts of Cr(VI) from solution, presumably through some adsorption mechanism.

It is apparent that sewage outfalls in the Triple Cities have affected both the river water concentration of Cr(VI), as well as those of the sediments. Recommended further work could include additional analyses of river water, with special emphasis on elucidating the nature of the nonionic Cr found in some water samples. A more extensive characterization of the sediment-bound Cr would also be of great use in tracing the pathways of the Cr released in the municipal and industrial sewages.

In addition, although a considerable amount of data has been collected concerning the uptake of and toxicity of Cr(VI) to some algae and duckweeds, further work might well include investigations concerning such toxicity and uptake in culture media more closely approximating river water (in our studies, Bristol's Solution was used) as well as an investigation concerning the toxicology and Cr-uptake by aquatic flora grown in contact with Cr-contaminated sediments.

Reference copy: SUNY/Binghamton Science Library

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Aquatic Quality and Socio-Economic Uses of the San Jacinto River Watershed (Grant no.GY-10760)

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May 14, 1973 - August 3, 1973

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Our project was an interdisciplinary study of the San Jacinto River Watershed. This is an area of approximately 2,828 square miles lying in Walker, Montgomery, Grimes, Waller, San Jacinto, Liberty and Harris counties in southeast Texas. The watershed is divided into two main regions: the upper Lake Conroe watershed and the lower Lake Houston watershed.

The research team was divided into four groups: biological, geophysical, sociological, and chemical-physical.

The biological survey group had two primary objectives. The first was to make a descriptive survey of the flora and fauna of the area by means of observations and collections in the field, and also by citing previously compiled data. The second goal was to make population estimates of terrestrial tracheophytes, benthic invertebrates, and plankton, by means of species diversity.

The descriptive survey of the watershed showed the area to be very diverse in both flora and fauna. The vegetation in this drainage basin is predominately altered pine-hardwood forests, interspersed with belts of open grasslands. The forest areas are characterized by mature pines with smaller oaks, hickory, sweet gums, and other hardwoods.

The species diversity per individual, $\bar{d}$, for phytoplankton in the new Lake Conroe Reservoir indicates that the water is of high quality. This is according to Wilhm and Dorris 1968, who state that $\bar{d}$ values larger than 3 indicate clean waters and values from 1 to 3 indicate moderate pollution. The only values below 3 were found in the first sample collection in June. All other values were above 3, with the highest being 4.07. The dominate genus of phytoplankton in the reservoir was found to be Ulothrix sp.

No set pattern of species diversity was observed for benthic organisms in Lake Conroe. The values ranged from a low of 0.64 to a high of 3.46. This can be attributed to the fact that Lake Conroe is a newly formed reservoir with a heterogeneous bottom, consisting of decaying trees, shrubs, grasses and many other types of vegetation, which would contribute to the concentration of certain bottom organisms in some locations and their absence in many other locations.

The geophysical group was concerned primarily with the present and changing land use patterns, soil limitations, and the determination of a sedimentation rate for the Lake Conroe reservoir. There is a definite physical difference between the upper and lower halves of the lake. The upper lake area is predominately grassland and clayey blackland soils. The differences are extremely important in relation to land use patterns and sediment distribution.

The 1990 land use statistics indicate that there will be a 12% increase in urban land usage and a 28% increase in residential land usage for the area. These increases will occur mainly in the southern portion of the watershed where there were 32 residential developments in June of 1973. When these increases occur, there will be a 12% decrease in open land and a 28% loss of forested land by 1990.

The geophysical group also estimated the sedimentation rate for the Lake Conroe Reservoir based on present land use. The estimate was that 306 acre feet of sediment would be produced per year. This would account for approximately 3.5% loss in total storage capacity by the year 2023. Most of this capacity loss will occur in the upper portion of the lake, where large amounts of sand will be carried into the shallow waters, producing a swampy condition.

The purpose of the sociological research was to survey the attitudes of the people in the developing area of Conroe, Texas in order to draw general conclusions about the effects of urbanization brought about by the close proximity of Houston, Texas and the Lake Conroe development. Conroe experienced a 30.2% increase in population from 1960 to 1970, and the growth rate is continuing to increase.

A random survey was taken of 1,000 people in the City of Conroe. Only 20% of the questionnaires were returned, thus we can only present a general analysis. Of the people returning the questionnaire, 74% were happy with the Lake Conroe development, 55% were happy about the growth of Conroe, 88% favored a rapid transit system from Conroe to Houston, and 43% were optimistic about Conroe's future. It was obvious that many people from Conroe utilize Houston facilities for buying clothes, medical facilities, entertainment and cultural events, and for buying large items such as automobiles. Those questioned felt that Conroe needed more of such facilities, along with improved traffic control.

The chemical-physical division of this project was concerned with the present and changing aquatic quality of the San Jacinto River Watershed. Water samples were obtained at critical points throughout the watershed. Eleven samples were collected each of 10 weeks from the upper Lake Conroe area, while 8 samples were collected biweekly from the lower Lake Houston area.

The water samples were divided into two portions, one being used as a sample for individual analysis immediately after gathering. The other was transported in an ice chest to the laboratory and refrigerated at 1° to 3°C until the analyses were performed. The temperature, flow rate, and dissolved oxygen of the water were determined in the stream before the samples were obtained. The parameters that were determined immediately following the collection include turbidity, nitrite and nitrate levels, pH, chloride, conductance, hardness, iron, sulfate. Parameters that were measured in the laboratory include bicarbonate, total suspended solids, ammonia nitrogen, orthophosphate, total phosphate, sodium, potassium, 5-day Biochemical Oxygen Demand, Chemical Oxygen Demand, and coliform count.

The water of Lake Conroe is of good quality, with the body of the new lake being of higher quality than the quality of the incoming tributary water. The water quality data from this summer were compared with data collected before the completion of the reservoir by another NSF-SOS project during the summer of 1972. Major improvements in water quality since the formation of the Lake include the decrease of hardness and sodium by over 50%, the decrease of chloride, conductance and Biochemical Oxygen Demand by over 40%, and the increase of dissolved oxygen levels by just under 50%.

In the comparison made between Lake Houston and Lake Conroe, the major differences in water quality were that the Lake Houston area water was more turbid, averaging 65.7 Jackson Turbidity Units to Conroe's 36.5 JTU's. Lake Houston area water was much more acidic, had higher concentrations of iron, sulfate, and ammonia, and was softer than the water of the Lake Conroe area. Both lakes possess water of generally good quality as indicated by the low mean Biochemical Oxygen Demands of 1.64 mg/l for Lake Conroe and 1.05 mg/l for Lake Houston.

Reference copy: Sam Houston State University Library.

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Cadmium, Copper, Lead, and Zinc: Trace Metal Pollution in an Aquatic Ecosystem (Grant no. GY-10814)

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June 4, 1973 - August 24, 1973

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The occurence, accumulation and effects of the trace metals cadmium, copper, lead, and zinc in an aquatic ecosystem were studied. These investigations involved the analysis of field samples and the performance of laboratory experiments on the accumulation of trace metals. The field sampling was conducted at four sites on the Fox River, Waterford Wisconsin, and Algonquin, Elgin, and Geneva, Illino

These areas represent respectively: rural and low density agriculture; rural, moderate density recreational; urban industrial; and suburban light industry. Samples of water, sediment, algae, benthic invertebrates, and fish were taken at each of these sites. The algae and invertebrates were identified to genus, prepared for analysis by dry ashing, and dissolving the ash in nitric acid. Sediments were wet ashed with nitric and perchloric acid for four hours. The water samples were concentrated and the trace metals extracted using APDC-MIBK. These samples were then analysed for concentrations of trace metals on a Varian Techtron Atomic Absorption Spectrophotometer. Corrections for nonspecific background absorption and proportional matrix effects were made. The chemical composition of the water was determined with a Hach Chemical Company water analysis unit.

The laboratory experiments included an investigation of the effects of varied combinations of the four trace metals on the composition and growth of microecosystems. The effects of combinations of the trace metals on the uptake of the metals in goldfish was also studied. Analysis of trace metals in the fish was the same as that for biological samples collected in the field.

It was found that, within the individual components of the ecosystem, a great deal of variability existed, which depended on the specific sampling site, particular area of the river from which the sample was taken, and in the species of organism being tested. It was found that the concentration of all four metals decreased with increasing depth in the river bottom sediment, indicating a binding of the trace metals in surface sediments. This trend could also be the result of a decreasing organic content with depth since it was found that samples with high organic content had high levels of trace metals. A second trend was a relationship to sediment type; gravels contained the lowest concentrations, lead concentrations were highest in the sands, and cadmium concentrations were highest in the silts. At Geneva and Elgin, the silt and sands showed similar concentrations of zinc and copper. The relative concentrations of trace metals always followed the pattern, Zn > Pb > Cu > Cd, at all sampling sites. Ranges of mean concentrations of surface sediments were: Zn 22-142 ug/g; Cu 8-51 ug/g; Pb 7-343 ug/g; and Cd 0.2-11 ug/g. The concentration of the trace metals in the river water was relatively low, well below the Illinois EPA pollution control standards.

The algae sampled at the three sites in Illinois were predominantly Cladophora taken from the dam faces. The relative concentrations of the trace metals were the same: Zn > Pb > Cu > Cd. Concentrations from the Wisconsin site were slightly lower for all metals. The trace metal content of the benthic invertebrates corresponded closely to that of the surface sediments. There was some variation among species of invertebrates, particularly concentrations of Cu and Zn which are used in blood pigments or metaloenzyme complexes. Crayfish, for example, showed high levels of Cu, due to the presence of hemocyanin. The concentration of trace metals in fish was significantly lower than that found in the invertebrates. Again, there was variation within sampling sites and among species, but relative concentrations were lower than in the sediments, invertebrates, and algae.

Thus the relative concentration of the four metals among the components of the environment were: Sediment > Detritus > Invertebrates > Algae >> Fish >>> Water. The invertebrates seem to act as an environmental block to the accumulation of the trace metals in the higher levels of the food web. This binding of the trace metals appears to occur in exoskeletons. These non-digestible hard body parts showed the highest concentration of metals. There was no evidence of accumulation at downstream sites, the concentration of trace metals being dependent upon local conditions.

The laboratory analysis of microecosystems indicated a relatively depressing effect on growth of Pb with Cd, Pb with Zn, and Zn with Cd, concentrations at maximum levels allowed by the EPA. Other combinations enhanced growth or had no effect on the growth after 43 days. Metals which were double the EPA standard concentrations generally showed depressing effects on growth.

Goldfish were exposed to various combinations of the four metals at EPA concentration limits. There was a significant increase in the accumulation of a trace metal in the fish when it was present in solution. The presence of other trace metals enhanced the accumulation. Thus, the general trend was for a synergistic effect between the studied metals.

Reference copy: Swan Parson Library, Northern Illinois University

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Environmental Effects of Pollution Control Measures by Two Puget Sound Paper Mills (Grant no. GY-10751)

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June 15, 1973 - September 15, 1973

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For the past 18 years, two sulfite pulp mills bordering on the Port Gardner area of Puget Sound have been discharging pulping wastes (chiefly sulfite waste liquor or SWL) into the water at a depth of 100 meters. There has been concern about the possible effects of this effluent on the marine life of the area, so much so that recently the Environmental Protection Agency established newer, more stringent pollution abatement requirements for the mills. There will be a reduction in effluent over the next few years; however, this reduction will come at great cost to the industries. The aim of this project was to set a biological, chemical, and geological baseline of the area prior to the reduction of effluents so that the environmental impact of these reductions might be more accurately assessed.

The sediment on the shores and in the Port Gardner Basin was studied, since the kind and quality of benthic marine life present is greatly affected by the characteristics of an area. Specifically, the geological objectives were:

1. Description of the regional geology and bathymetry;
2. Description of the physical characteristics of the surface sediments--size, texture, color, odor, biogenous contributions;
3. Measurement of organic content of the sediments, distribution of volatile solids.

Parameters in water chemistry were studied over the entire basin in order to estimate:

1. The three dimensional and temporal (tidal) variations within the effluent field, as a measure of where marine life might be most affected;
2. The degree of influence of this field upon the distribution of dissolved oxygen;
3. The effects of flushing coincident with a sharply decreased or terminated outflow of pulping wastes, as this would provide insight as to how rapidly the area could purge itself of waste materials.

Lastly, two marine biological communities were heavily sampled to determine the distribution of species in the area. The chemical survey initially noted a maximum effluent concentration at 75 meters. On this basis, a survey of benthic life above, at, and below this depth along the southern portion of Port Gardner was undertaken.

Initial chemical studies also showed the existence of a longshore current in the surface layer along the southern shore. Thus, if any effluent were reaching the highly productive surface waters, the effects would be noted within the upper 20 meters of water along the southern shore. Scuba diving, beach seining, 1/4 m^2 quadrat sampling, and crab trapping were all employed in the study area.

Sampling for geological data included the collection of samples from onshore, beach subtidal, and deep water sediments. All samples were collected manually where possible, deep water samples being collected with a 0.1 m^2 Van Veen grab. All samples were analyzed for volatile content and random samples were chosen for granulometric analysis. X-ray petrographic analyses of onshore and beach samples were made for comparative studies in determining the source of beach sediments. In the field, data were collected concerning location, elevation or depth of station, color, and odor of sample.

The chemical water sampling program was designed on the assumption that sulfite waste liquor concentrations at any location would be highly variable over time, being affected by such factors as river outflow, tide currents, and variations in the rate of effluent outflow. Ten stations for water sampling were chosen over the area and samples were taken at the same six depths at all stations. Seven cruises (18 days) of ship time were scheduled to include sampling over spring, neap, and mid-tide periods. On each cruise, four of the 10 stations were chosen, either in a trapezoidal pattern over the whole area or in a straight line transect from the diffuser, for repeated sampling at two-hour intervals. Each group of stations would then be sampled repeatedly over a full tide cycle to determine temporal variations in the chemical parameters. Water was analyzed for sulfite waste liquor, dissolved oxygen, in situ temperature, and salinity. Standard methods were used in all cases.

Over 10,000 samples were collected in this manner over the summer. All SWL and dissolved oxygen data were plotted as concentration versus time to determine temporal fluctuations. Extreme fluctuations were noted in both parameters; the verification of this will necessitate the continued use of time series studies similar to this one for future monitoring. Median SWL concentration values for the summer were plotted to delineate the spatial distribution of the effluent plume. Plots of SWL concentration versus time were used for determining the flushing characteristics of the area.

In the deep water benthic survey, replicate Van Veen grabs were taken at a grid of stations and washed through a 1 mm screen. A grid of eight transects perpendicular to the shore, each with three to five stations, was set up to cover the area. Data were plotted as number of various organisms versus distance along the shore from diffuser.

The subtidal and intertidal work was conducted along 15 short transects perpendicular to the southern shore. A 1/4 m^2 quadrant was used in conjunction with screening to sample benthic macrofauna larger than 2 mm. Diving and seining work surveyed those mobile or rare organisms which would not fall within a 1/4 m^2 quadrant. Triplicate crab traps were set at three different depths along three of the transects to determine the size distribution of the commercially important species, *Cancer magister*. Intertidal work was done at five depths and subtidally at seven depths, replicate surveys being done in all cases. All data were plotted as number of organisms *versus* distance along shore from diffuser.

The distribution of sediment and variation in these parameters reflects unequal sorting by flow and unequal settling rates, along with a relationship to bottom configuration. There is a gradation of sediment size offshore with sorting from the Snohomish River mouth, the major source of sediments for the central basin of Port Gardner. Shore sediments are a result of degradation of the surroundings sediments (as demonstrated by X-ray petrographic analysis) prior to or during transport to the beach, although there is also *in situ* reworking of sediments by waves and shore currents. The distribution of volatile solids closely reflects the sediment distribution, with the exception of the Everett Harbor area which has an especially large input of volatile solids. Elsewhere, the mean sediment size is inversely proportional to the volatile content, although this relationship is further modified by the velocity of water flow over the sediments and the configuration of the submarine floor. Generally though, the volatile content increases with distance from shore, reaching a maximum in the fine poorly washed sediments of the central basin.

Plots of chemical data showed the existence of a bi-layer circulation system in the basin when dense salt water moves north and underlies fresh water from a nearby river which moves southwest. Water circulation in each layer, thus, behaves relatively independently of that in the other, which results in a complex circulation pattern for the basin. This bi-layer system also allows for little verticle mixing so that effluents introduced into the deep layer are not likely to reach the surface in high concentrations. Circulation is also less in the deep layer so there is a constant maximum concentration of effluent at about 75 meters. The median value of effluent concentration in this layer is about 25 times background (122 ppm vs 5 ppm background). A definite and inverse relationship between SWL and dissolved oxygen was demonstrated in the deeper waters, although it is not known whether the resulting low oxygen concentrations affect the marine life there. Extended time series studies over a Fourth of July mill closure showed a large decrease in ambient effluent concentrations in the deep layer when the source of effluent was shut off. It is expected, then, that the deep effluent concentration maximum will rapidly dissipate if and when effluent disposal into the water is stopped. It is impossible to say, however, whether concentrations will immediately return to natural levels or remain at a slightly higher than normal concentration for an extended period of time while sediments are purged.

Biological sampling revealed a great deal of patchiness in both communities. The benthic survey showed that crustaceans and molluscs comprised the bulk of the total invertebrates of shallow depths (30 m - 50 m), dominance being shared with polychaete worms at intermediate (75 m) and deep (100 m) stations. Generally, there is no trend in abundance of life forms moving away from the effluent source. Increases and decreases in numbers of species are probably more related to sediment characteristics than anything else.

Intertidally, crustacean abundance could not be related to distances from the diffuser. Molluscs and polychaete worms both show nonuniform distributions with depth and distance, probably due to sediment parameters and amount of exposure. Subtidal organisms show a general trend for high concentrations half-way down the beach, dropping off both near to and far from the effluent source at the diffuser. Seining data showed two trends where fish were either present near the diffuser and not present far from it or vice-versa. A definite correlation between stream inlets and number of organisms caught was established for some species of salmon. Crab trapping showed a general trend of increasing numbers with distance from the diffuser and also increasing numbers with depth going away from the diffuser. Many factors including changes in water quality or sediment parameters could be the cause of this trend.

Reference copy: Fisheries-Oceanography Library, University of Washington

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Study of Colonization and Development of Corals on an Artificial Reef Substrate (Grant no. GY-10773)

University of Hawaii
Honolulu, Hawaii 96822

June 1, 1973 - August 24, 1973

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The study described here was a biological survey and experimental investigation of the car body artificial reef area one mile south of Pokai Bay, Oahu, Hawaii. Four study stations were used. These included two stations within the artificial reef area and two (for comparison) outside the artificial reef area. The specific biotic interrelationships studied were: 1) the algae/coral competition for available substrate; and 2) the grazing of algae by the recruited herbivorous fish population and its effect on the colonization and development of corals. Quantitative measurements and observations were taken for algal, coral and fish populations. Selected physical and chemical parameters were examined to determine their influences on the biotic components studied. Experiments were conducted with wire mesh cages to eliminate fish grazing on the artificial and natural substrates.

The results of the study indicate that, on the natural calcareous substrate, the algae/coral interrelationship is not noticeably affected by the recruitment of herbivorous fishes. No significant differences were found in the standing crops of coral and algae at stations within and outside of the artificial reef area. This may be due to: 1) the lack of recruited fish grazing on the dominant algal species which covers a larger percentage of substrate suitable for coral colonization; and 2) the limited presence of such suitable substrate.

On the artificial substrate, the experiment in which herbivore grazing had been eliminated, demonstrate that the recruited fish population may be a factor in the colonization and development of corals. It must be noted that the algal succession on the artificial substrate at the time of study had not reached climax community. The algae at the time were primarily of filamentous forms. With these filamentous forms as preferred dietary items of the herbivorous fishes, as indicated in a dietary survey conducted, grazing may reduce algal dominance on the substrate providing a more favorable condition for coral colonization. Because of the unstableness of the car bodies over a long period of time (because of erosion and corrosion by sea water) it cannot be expected that the settled corals will reach maturity.

Reference copy: Ocean Science Information Center, Hamilton Library, University of Hawaii

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Caretta caretta on Kiawah Island, South Carolina: Offspring Increases, Population and Predation Studies (Grant no. GY-10818)

University of South Carolina
Columbia, South Carolina 29208

May 22, 1973 - August 15, 1973

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The objective of the present study was to assess the value of the Kiawah Rookery for marine turtles in terms of nesting density, population of female adult Loggerheads, predation, and to monitor various environmental parameters affecting the status of this rookery. The relevant data were collected and recorded on nightly beach patrols throughout the nesting season. As nesting activity tapered off, the data were assimilated and analyzed by the members of the project staff. A list of the most crucial information on each tagged adult female was then sent to the University of Georgia, where it was incorporated into a computer record which is updated on an annual basis; this combined Kiawah data with that of the University of Florida, from which a tagging study encompassing the Southeast United States and the Gulf Coast is monitored.

The Kiawah tagging study tallied 61 adult females, representing some 80% of the 1973 population of nesting Loggerheads; the total number of nests was 192, compared to 197 in 1972. Over the next decade, if the tagging study is permitted to continue with the system described above, we expect to tally some 200 to 300 adult females utilizing the Kiawah Rookery.

Because developmental pressures on the South Carolina Coast have decreased the number of native rookeries accessible to the Loggerheads, and have also concentrated nest predators on the remaining undisturbed islands, predation of nests and hatchlings on Kiawah has skyrocketed above the 90% mark. In addition, the number of adult and adolescent female Loggerheads drowned accidentally in offshore Kiawah waters during the nesting season is on a dramatic increase, to the extent that the annual hatchling crop is no longer sufficient to offset even this singular drain on the faltering adult population. For this reason, the present study initiated a hatchery system for Loggerhead nests in the hope of effecting a dramatic increase in the hatchling crop at Kiawah. The project staff transplanted 50 nests into protective pens, and these nests were monitored throughout the incubation period. The mean hatch rate was 80.58%; a hatchling crop of 4,990 was yielded. In a separate pen, 11 nests were transplanted between 5 and 50 days after the date of oviposition, in an effort to obtain more accurate and reliable data on embryonic sensitivity during the incubation period. Mean hatch rate among these 11 nests was 64%, with a yield of 757 hatchlings. With a total of 5,747 hatchlings from this hatchery, and some 2,800 hatchlings produced from control and singularly protected wild nests on the beach, we were only able to offset the mortality rate among adult and adolescent females during the 1973 season. If this mortality rate continues to increase on an annual basis, the hatchery system will have to be expanded and made more efficient.

Emergences of nesting Loggerheads were analyzed with respect to time and tide levels in hopes of effecting a greater efficiency in beach patrols. These data indicate that the most intense nesting activity occurs on nights with a high tide before 2:00 a.m. EST. An analysis of emergent data throughout the nesting season confirmed our 1972 suspicions that group nesting is a phenomenon which does occur on Kiawah, and this information should be of use in future studies. Analyses of meteorological and beach topographical data indicate that nesting activity is not affected significantly by meteorological phenomena, and that topographical cues to nesting adults are essentially overriden by human habitation of, and presence on, nesting beaches.

In addition to the biological field work conducted on Kiawah in 1973, an ecological documentary was assembled in the form of a black and white 16 mm film, with sound, which can be obtained for private or group showings through the Baruch Institute of the University of South Carolina. The film is a record of the project activity, and it describes the plight of Caretta caretta on Kiawah and other South Atlantic rookeries. As an educational tool, this is the most immediately important product of the 1973 research.

If the present study is to benefit the Loggerhead population at Kiawah, it must be continued for a period of at least a decade; its success, therefore, depends on the Baruch Institute's future access to the Kiawah Rookery.

Reference copy: P. S. C. Science Library, University of South Carolina

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Section II.

Health-Related and Basic Studies

Papers from the University of Georgia, University of Wisconsin at Madison (2), Hope College, William Marsh Rice University (2), Niagara University, Seton Hall University, University of Oregon, Manchester College, Benedict College, Massachusetts Institute of Technology, Southwestern State College, Texas A&I University, Arkansas State University, Yale University, Morehead State University, Northern State College, Vanderbilt University, Purdue University, University of Maryland, Reed College (2), University of Pennsylvania, and The Johns Hopkins University.

Identification of Man-Made Reservoirs for Human Pathogens in the Human Environment (Grant no. GY-10802)

University of Georgia
Athens, Georgia 30602

June 11, 1973 - August 31, 1973

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Human bacterial and fungal pathogens were isolated from ornamental planters in two suburban shopping malls, a children's day care center and the University of Georgia campus during a three-month period. Human contact at all test sites was also monitored.

Soil samples were collected in sterile plastic bags, using stainless steel spoons; these samples were tested in the following manner:

Fungal: Soil was first overlaid with sterile hair according to the hair-baiting technique for dermatophytes. Soil dilutions were made and inoculated on Sabouraud's dextrose and Rose Bengal with .015% streptomycin. Isolation of other fungi was accomplished with these two media.

Bacterial: Soil dilutions were inoculated on nutrient agar, Streptosel, blood agar, and tellurite glycine base agar.

Resulting cultures were stained by the Gram method and subcultured on nutrient agar slants and brain-heart infusion broth. Identification of the genera was made by the use of fermentation tests (dextrose, saccharose, mannose, lactose), motility, hydrogen sulfide, indole, liquefaction, citrate, methyl red, Voges-Proskauer, and catalase tests.

From the sample areas, common soil organisms and human pathogens were isolated. Bacterial pathogens consisted of:

Staphylococcus spp.
Streptococcus spp.
Micrococcus spp.
Pseudomonas spp.
Neisseria spp.
Enterobacter spp.
Salmonella spp.
Escherichia coli

Fungal pathogens consisted of:

Microsporum spp.
Trichophyton spp.
Epidermophyton spp.
Aspergillus spp.
Penicillium spp.
Phialophora spp.
Cephalosporium spp.
Cladosporium spp.

Experimental Planters

Planter number	Type of mulch
1	pine bark nuggets
2	control
3	pine bark chips
4	morr
5	mull
6	unmulched*
7	pea gravel*
8	peat moss
9	pea gravel

* These planters contained peat moss as a planting base.

Rank of Inhibition*

HIGHEST INHIBITION	FUNGAL COLONIES	BACTERIAL COLONIES	YEAST COLONIES
	2	2	2
	7	6	7
	6	7	3
	9	9	5
	8	5	6
	5	8	4
	4	4	9
LOWEST	3	3	8
INHIBITION	1	1	1

* Numbers indicate the number of the experimental planters.

Soil constitutes a natural environment for microorganisms pathogenic for man. The soil in ornamental planters (of the type found in shopping malls) also contain microorganisms which may be inimical to man. Through random observation of isolated planters located in congested shopping malls, a 12.4% contact rate with planters was found. Therefore, if bacteria or fungi are present in these planters, a reservoir of contamination and a possible mode of transmission of disease has been established. The presence of those bacteria and fungi was confirmed in this study. As stated by Gray, in a list of bacteria indigenous to soil, Streptococcus and Staphylococcus are not natural inhabitants of soil. However, these organisms were found in this study.

It can be concluded that it would be possible for shoppers and others to inoculate themselves with microbes when touching a planter. By the use of experimental planters, it was found that the best means of controlling pathogenic organisms in the planters was the removal of mulch from the soil. Alternate planters were also designed to minimize the contact rate. These designs, if used would control the spread of disease. It is recommended that inanimate objects--chairs, benches and the surfaces of the planters--be sprayed with a disinfectant to minimize the possibility of human contamination.

Reference copy: Science Library, University of Georgia

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Development of a Device to Accelerate Communication in Mute, Severely Handicapped Children (Grant no. GY-10746)

University of Wisconsin at Madison
Madison, Wisconsin 53706

May 27, 1973 - August 22, 1973

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This report presents a condensation of the results of the research efforts of the Cerebral Palsy Communication Group during the summer of 1973. During this time the group conducted the initial research and development of a new aid, the Wordmaster, whose purpose is to accelerate communication for non-vocal, physically-handicapped children who are presently using a communication aid which includes some form of printout. The acceleration of communication is to be realized by providing the child with a limited set of words which would be printed out automatically when he selected them. Thus, the child would be able to communicate in a word-by-word fashion as in normal speech instead o-f- -h-a-v-i-n-g -t-o- -s-p-e-l-l- -e-v-e-r-y-t-h-i-n-g- -o-u-t- -l-e-t-t-e-r- -b-y- -l-e-t-t-e-r-, -w-h-i-c-h- -i-s- -a- -s-l-o-w- -a-n-d- t-e-d-i-o-u-s- -p-r-o-c-e-s-s-.

The research accomplished is categorized by three problem areas: a) those problems that arise from trying to base an entire communication system on a very limited wordset (64-128 words); b) the problems involved in drawing up a simple, straightforward scheme for the children to reference and specify the proper word for printout; and c) the design, testing, and perfection of a device to accomplish the task.

The Wordmaster device was designed in modular form so that it could be adapted for use with any device using standard ASCII code. For the summer research, the Wordmaster was developed to work with the Auto-Com, a communication aid developed earlier by the Cerebral Palsy Communication Group.

The results of the summer program were:

1) Specification of 2 Wordmasters

Upon investigating the needs and uses that the Wordmaster would fulfill, it was found that they fell into two broad types of communication. It was also determined that these needs could best be handled by two different Wordmasters, each designed to handle one of the two types of communication. The Portable Wordmaster (PWM) would be designed to fulfill the everyday conversational needs of the person, while the Stationary Wordmaster (SWM) would be planned for more comprehensive communication, such as papers, letters, and other work which would normally be written.

2) Computer Modeling of the Wordmasters

Both versions of the Wordmaster were modeled on a PDP-11 mini-computer. They were designed in such a way that the PDP-11 functioned exactly as the Wordmasters would when completed. These models were then used to study both the operational characteristics of the Wordmasters and, later, to test the various forms of the vocabulary as it was being developed.

3) Designs for Both Wordmasters

Complete logic designs were made for both the Portable and Stationary Wordmasters. These designs were based upon the features determined from the computer models.

4) Construction of a Prototype of the Portable Wordmaster

Based upon our projections for the uses of the two Wordmaster models, it was decided that the Portable Wordmaster was more fundamental and fulfilled a more essential function than the Stationary Wordmaster. The Portable Wordmaster was, therefore, given priority and the remainder of the summer effort was directed toward developing a working prototype of it. This prototype was completed and installed in a specially modified Auto-Com. Hereafter, the total assembly will be referred to as the Portable Wordmaster/Auto-Com (PWM/AC).

The PWM/AC was completed during the summer program but final debugging was not completed until the 1973-74 school year. The system is now fully functional.

5) Development of a Limited Word Vocabulary System

While the engineering section was working on the design and construction of the Wordmasters, the Communication Research section was investigating the problems associated with the vocabulary. The major result was the 63-word vocabulary-set, along with support materials, such as the dictionary and the surface display organization. The wordset was limited to 63 words by the number of squares on the Auto-Com surface. Additional words have been provided by using a level system.

6) Recommendations to Expand Function of the PWM/AC

In addition to the design and development of the vocabulary "cover" set, the team has made recommendations for techniques and methods to expand the function of the communication device. These suggestions involve modifications for display and/or usage of characters appearing on the surface of the board.

7) Evaluation Program for the Final Model

An evaluation program was designed to assess the Wordmaster/Auto-Com as a means of communication and as a device for social and academic advancement. Usage and evaluation of the device will determine its appropriateness, educational relevance, and possible modifications.

The results of this project provide both specific and secondary benefits to those who suffer from communication handicaps. Immediately, it has made available a device which can accelerate communication for non-vocal, physically-handicapped individuals who are or will be using printing communication aids. This apparatus will be evaluated and will be in marketable form by August 1974. In a much more general vein, the vocabulary research has laid the foundation for the development of a limited-word vocabulary system for children that has application far beyond its use in the Wordmaster or other electronic communication aids. Such a word-set, when finally developed, will have implications for a large variety of individuals with communication handicaps, including the deaf. The research into the development of a communication word-set is continuing.

Reference copy: Memorial Library, University of Wisconsin at Madison

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Neighborhood-Mental Retardate Interaction Effects During the Deinstitutionalization Process (Grant no. GY-10748)

Hope College
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May 14, 1973 - August 24, 1973

Participants

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Patrick R. Harrison, Faculty Advisor

An accelerated movement of adult mentally-retarded individuals from state institutions and into community-living situations, as well as a gap in the retardation literature describing the day-to-day life style of the retarded, prompted an investigation into five homes organized for the care and "normalization" of mentally-retarded adult males. The house populations ranged from three to ten residents, (ages 19 to 50$^+$). Each home is staffed by a set of house parents. The houses have been in operation for 0 to 6 years (two were established during the study.) To ascertain descriptively what type of behaviors an individual had exhibited while institutionalized, institutional records were analyzed exhaustively and a retrospective Vineland Scale of Social Maturity was compiled. This scale measure was repeated at the end of the three-month study, and again three months after the completion of the study. Also, Wechsler Adult Intelligence Scales, which are characteristically given at the time of institutional release, were gathered from the subjects' institutional files to compare with the same scale applied at the end of the study.

Throughout the summer, naturalistic observational techniques were used to record the components of the retardates' life styles. These included the video-taping, cassette-recording, and super-8 filming of activities in which the retardates were found to be taking part at the randomly-selected times the observer was present. These permanent records were then viewed for characteristic behaviors which the retardates exhibited. This series of behaviors was compiled into a coding-sheet, which was then used to count each behavior and list the conditions under which it occured.

The second component of the naturalistic phase of the study was a behavior-check sheet compiled from two weeks of unrestricted observation, during which time the observers collected exhaustive descriptions of the behavioral repertoires of each retardate. Two forms of the checksheet were then compiled.

The first was used by the observers and contained broad activity and behavioral descriptors likely to be seen during the four weekly two-to-three hour observation periods. The second form was used by the houseparents and noted specific behaviors which they might have observed during the day. Thus, the study attempted to catalog, in broad terms, the activities of each of the 27 retardates each day for eight weeks.

To discern the effect each house had on its neighborhood, the inhabitants of the nine houses adjacent to each retardate house were unobtrusively polled on their attitudes concerning their neighborhood, their house, old age-organizations, public education, and (quite coincidentally) mental retardation. In this way, the interviewees were never aware that the survey had any relationship to the retardate house. Finally, a survey was made of all County mental health agencies regarding similar houses they had organized.

With this approach, using standardized measures of intelligence and social adaptation, constructing records of behavioral observation by both trained observers and the houseparents, utilizing attitude questionnaires and institutional records, the study attempted to construct a complete picture of the effects the deinstitutionalization process had upon the retardates and their neighborhood.

The changes in Vineland Social Maturity scale scores indicate that an improvement in social skills was realized (across individuals) from release to the end of the study and, again, three months later. The biggest change in scores occurred for moderately-retarded individuals recently released from the institution. Although this group accounted for the largest average change, all individuals in this group did not exhibit big changes.)

WAIS scores also improved from release-time to the end of the study. Again, the moderately-retarded, recently-released group accounted for this change. Although a statistical analysis was impossible because of the discrepancy between institutions and because of our way of collecting the data, it appears that fewer hospitalizations and aggressive acts occur outside of the institution, while mail exchange remains unchanged. Given the measurement constraints, this must be considered only tentative.

The observational portion of the study yields highly complex results which do not easily reduce to generalizations without the use of multi-variate analyses, unavailable at the time of writing of this abstract. This much can be said on a tentative basis: several individuals did exhibit a change in the frequency of several behavior-groups. There was, as the summer progressed, an increase in "behaving"; that is, the frequencies of several categories increased so that the activity level was generally heightened in most houses. Many lower-level retardates show a marked (although not necessarily large) frequency of imitative behavior--imitating either the television or other retardates. A disproportionate amount of time (in some cases more than 50% of the samples taken) is spent listening to radios, stereos, tape recorders or watching television. The behavioral level seems to increase when the houseparent is present, and it is anticipated that the presence of the houseparent may prove to be an elicitor or inhibitor of behavior when a multivariate analysis is made.

The attitude questionnaire gave the most clear-cut and the most useful results. Contrary to expectation, neighborhoods with retardate houses viewed their neighborhood no less favorably than control neighborhoods (identical save for existence of a retardate house.) Their views toward the neighborhood as a place to bring up children and as a financial investment apparently had no relationship to the presence of the retardate house. They rarely mentioned the existence of the house, and when they did, it was more often favorably than unfavorably. Nor were their reported attitudes toward mental retardation any different than in control neighborhoods. It should be noted that if any neighborhoods could be said to have "negative" attitudes, it was the groups in which retardate houses had most recently been established (although this difference is only marginal) and which had, as yet, only negligible contact with the house.

Doubtless, the most dramatic change occurred in the occupations of the retardates. At the beginning of the summer, 17 worked in a sheltered workshop (5 on the farm on which they lived), 5 were competitively employed, 4 went to school and 1 was unemployed. At the end of the summer, 14 worked in a sheltered workshop (5 remained on the farm), 9 were competitively employed, 4 went to school and none were unemployed.

While the results of a study carried on for only three months, observing only 27 non-randomly chosen individuals (with as varied histories as these individuals had), must be regarded as only tentative, it appears that many, if not all, retarded individuals benefit from community-living, with no apparent detriment to the community's well-being.

Reference copy: Yoeren Public Library, Hope College

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Circadian Variations in the Need and Administration of Antihistamine (Grant no GY-10762)

Rice University
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May 14, 1973 - August 3, 1973

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Although daily variations in the response of animals to different drugs have long been known, very little is understood about where these variations come from. The antihistamine drug system was used as a model to investigate the component rhythms of the various elements of the system, in an attempt to elucidate their relationships to the overall rhythm of the system. The model consisted of Compound 48/80-releasing histamine, which competitively interacted with an antihistamine (chlorophenirамine maleate) to produce various effects. Different elements of this sequence were isolated and their rhythms determined through use of appropriate controls. The system was studied in laboratory rats which were adapted to a 12-hour light/12-hour dark cycle. Body temperature was chosen as the symptom to be measured. A rectal temperature assay was perfected and used in these studies. The basal temperature rhythm and the rhythm of response to 48/80 were found. Next, the overall rhythm was found, using this assay. An attempt was made to isolate the mast cell receptor rhythm for 48/80 by measuring the amount of histamine released by the 48/80 into the plasma. A double dilution isotope enzyme assay for histamine was used without success for this experiment and for an experiment to determine the rhythm of the basal histamine present. Thus, these two rhythms could not be determined. However, the temperature response rhythm to injected histamine was found using the temperature assay. Finally, the rhythm of the antihistamine was isolated using the temperature assay. With the major rhythms established, attention was turned towards investigating the catabolism of the various drugs in the system. No assay for antihistamine in blood plasma could be devised, so the delayed action of its effects were investigated. Only one time period was found in which catabolism did not reduce the drug effects to zero. To measure histamine catabolism, H^3-histamine was injected into the rats, plasma samples taken and assayed 5 hours later. Data from this experiment were neither significant nor conclusive.

In summary our efforts were successful in a variety of areas. A temperature assay for histamine was perfected, and used to determine the overall rhythm and the rhythm of the effects of 48/80, histamine, and the antihistamine. A rhythm of the delayed effects of the antihistamine was also found. Integration and inspection of these rhythms has shown that no single factor seems to control the overall rhythm, but, rather, that the component rhythms interact in a complex manner to produce the overall rhythm. The rhythms which were found can be manipulated to predict the mast cell receptor rhythm, which, itself, could not be determined, because of the failure of the enzymatic assay for histamine. Determination of this final rhythm will provide a link between the relative potencies of the two drugs, allowing a determination of the relative importance of each component rhythm in describing the overall rhythm. Categorizing drug response rhythms in this fashion will provide information about how these rhythms interact with each other, thus providing insight into the mechanisms of drug action within the animal.

Reference copy: Fondren Library, Rice University

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The Effects of Sulfur Dioxide on the Respiratory Capabilities of the Laboratory Rat (Grant no. GY-10784)

Niagara University
Niagara University, New York 14109

June 4, 1973 - August 24, 1973

Participants:

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Sulfur dioxide is a common urban pollutant known to cause chronic lung irritations resulting in bronchoconstriction and decreased respiratory volume. Since respiration plays an important role in the regulation of blood pH, sulfur dioxide in an inordinately high concentration of 5.24 ppm should cause either an uncompensated or a compensated respiratory acidosis. This problem can be detected by obtaining pCO_2 and pH values with a blood-gas apparatus. Sulfur dioxide is also known to increase the red blood cell count, hemoglobin concentration and packed cell volume. These changes were examined.

Prior to the initiation of the toxicological study, two environmental chambers were constructed of plexiglas. They were rectangular in design and proved to be quite inexpensive and versatile. The pollutant gas was introduced into the chambers via a nalgon tubing dilution system which functioned by using "bleeds" (constrictions) in the tubing that offered a resistance to flow. With this method one could readily divert large quantities of the gas from the experimental chamber, so that the desired concentration was obtained. Analysis of the actual concentration of sulfur dioxide in the experimental chamber was made by the wet chemical method of West and Gaeke. This involved converting the sulfur dioxide to a disulfitomercurate anion by scrubbing it through a 0.1 M tetrachloromercurate II solution. This anion can be detected spectrophotometrically with the addition of acid bleached-pararosaniline and formaldehyde. Concentrations are determined by comparing the sample to a prepared standard curve which plots absorbancy against disulfitomercurate concentration.

With a proper environment established, 36 Sprague Dawley rats were numbered and weighed. Eighteen were introduced into the control chamber and 18 into the environmental chamber. Air entering each chamber was filtered, and, except for the sulfur dioxide gas entering the experimental chamber, all other conditions were identical.

Every week, 9 rats from each chamber were selected, and 1 ml of blood taken from each by means of a cardiac puncture of the left ventricle. The next week, the remaining 9 rats from each chamber were chosen for sampling. By this method, a weekly progression could be observed. Six tests were performed on the blood: hematocrit, hemoglobin determination, red blood cell count, pO_2, pCO_2 and pH, with a subsequent calculation for HCO_3^-.

With these values known, it could be determined easily whether the sulfur dioxide had had any effect on the blood. After subjecting the data to Student's T Test, no changes in the blood-gas values or other blood values were found for a seven-week period at a mean concentration of 5.24 ppm. These results may be explained by the following: a seven-week period is not long enough to effect a change; the concentration was not strong enough; or the rats were too resistant to the gas under these conditions to induce a change.

Reference copy: Niagara University Library

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Correlation of Atmospheric Trace Metal Concentrations with Body Burdens in Newark, New Jersey (Grant no. GY-10755)

Seton Hall University
South Orange, New Jersey 07079

June 6, 1973 - August 26, 1973

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The purpose of this project was to determine if there is a correlation between the concentrations of atmospheric trace metals (particularly cadmium, copper, lead, nickel, and zinc) with body burdens, in the urban Newark, New Jersey area. To carry out this investigation, daily air samples were obtained to establish local distributions and correlations with atmospheric data; blood samples from young children in Newark were analyzed to determine whether a correlation exists between concentrations in the air and in the blood; and a typical diet of an inner-city Newark child was examined to investigate the significance of food consumption on body burdens.

Air samples containing particulate matter from the atmosphere were collected on 8 X 10-inch sheets of filter paper placed in high volume air samplers at five different locations in Newark, and one location each in East Orange, South Orange, Maplewood, Kearny, and Jersey City. Samples were taken every weekday at each location. Sampling periods were approximately 24 hours for each station. The filter paper was analyzed by means of X-ray fluorescence spectrometry, using a method developed by Luke, _et al_., at Bell Laboratories. This method requires no sample treatment and is nondestructive. Forty-second counts were made on a General Electric XRD - 5 unit at goniometer readings specific for each element. A scintillation counter tube served as the detector. The instrument was calibrated regularly, using multimetal standards. Due to inherent difficulties, cadmium could not be analyzed by this method.

The blood samples were analyzed by atomic absorption spectrophotmetry, following a method described by Hessel. Blood samples were treated with a combination of hemolyzing and chelating reagents, followed by the extracting solvent. Each sample was centrifuged and the supernatant aspirated directly into the spectrophotometer. The New Jersey College of Medicine and Dentistry supplied all blood extracts. These extracts were examined for lead and cadmium.

The purpose of the food analysis was to compile an average weekly diet of typical 2±0.5-year old Newark children and to determine the trace metal concentrations in this diet for further correlation with trace metal body burdens. A diet was prepared from data taken from 54 nutritional questionnaires collected at the Martland Hospital clinic, in conjunction with the lead screening program. The food items contained in the diet were purchased at an inner-city supermarket. The food was prepared and blended with 100 ml. of formaldehyde added to retard spoilage. The food was analyzed, using a low-temperature ashing technique and atomic absorption spectrophotometry.

Correlations between ambient trace metal concentrations and daily meteorological data were established using a linear regression analysis program from a computer library. The most significant correlations were found between the ambient metal concentrations and the average daily wind speed. It was concluded that, in most cases, the ambient zinc and nickel concentrations are inversely proportional to the average daily wind speed.

The blood level concentrations were plotted for lead and cadmium on a large map of Newark and vicinity. The goal was to establish a mean concentration value for lead and cadmium around each air sampling station and to compare these values with the average ambient trace metal concentrations for possible correlations. An analysis of variance indicated, however, that all blood level concentrations were statistically from the same population and means at each station could not be distinguished.

Reference copy: Sciences Library, Seton Hall University

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The Effects of High-Intensity Noise and Injected Tranquilizers on Social Behavior and Corticosterone Levels in Rhesus Monkeys

(Grant no. GY-10787)

University of Wisconsin at Madison
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May 29, 1973 - August 17, 1973

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This experiment was designed to determine some of the effects of tranquilizers on the behavior and on steroids in the blood of rhesus monkeys exposed to noise. The work involved 18 animals, divided into three groups of six each, so that three types of tranquilizers could be studied without inter-drug effect. The design was 6 X 6 Latin square, with the square repeated for the three drugs. Each of the 36 squares represented one combination of noise treatment and drug dosage.

The type of noise, one hour of continuous power tool noise, was chosen as a result of an SOS project on noise pollution at the University of Wisconsin under Perry M. Nealis. This mode (for this particular length of time) gave the greatest level of blood cortisol--a stress-related index, according to the 1972 study. The tranquilizers were chosen because of their high level of human usage and because they belonged to different tranquilizers groups. Valium (or diazepam) is a member of the benzidiazepine group and is the most often prescribed drug in the United States. Vistaril (hydroyzine hydrochloride) is also widely used for the alleviation of anxiety. Stelazine (trifluoperazine) is one of the phenothiazines and used in the therapy of psychoses.

It was found that cortisol levels were significantly affected in a tranquilizer-noise parameter. For example, with all dosage levels of Stelazine, the cortisol levels of the no-noise condition were 13.8 ug % higher than the cortisol levels of the noise condition. This may indicate an increased responsivity and a correspondingly less-stressed state of the animals given Stelazine in the presence of noise.

Behaviorally, two categories (social play and self play), were shown to have been significantly affected by the noise/no-noise condition with respect to both tranquilizer type and dosage received. For these two areas, noise appears to increase these behaviors in the low and high dose conditions for Valium, while the lack of noise decreases social play and has no effect on self play. The low dosage of Vistaril used on the monkeys seems to loosen the inhibition of the animals and, thus, facilitate social behavior. High dosage, however, depresses all normal behavior, as compared to the low dosage behavior; the combination of noise and low dose Vistaril is behaviorally comparable to high dosage and no-noise. Stelazine appears to abolish all normal behavior in both dosage and noise conditions. Unlike the other two drugs, a low dosage is sufficient, in all cases, to elicit the behavioral effects. As expected, a drastic increase in disturbance level was found.

The last area of noise-related significance concerns passivity. Both Valium and Stelazine showed decreases in the passive behaviors when comparing no-noise conditions to noise conditions. This would support the theory that noise creates an increase in behavioral responsiveness for these two drugs. On the other hand, there was an increase in general passivity for Vistaril with noise vis à vis no noise, indicating a decrease in behavioral responsivity for this particular drug.

Other behavioral categories showed significant effects with respect to tranquilizer and dose alone and are discussed in the technical report.

Reference copy: Memorial Library, University of Wisconsin at Madison

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Effects of Artificial Polycythemia on Selected Physiological Responses to Strenuous Exercise (Grant no. GY-10767)

University of Oregon
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June 10, 1973 - September 1, 1973

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The objectives of this study were to test the following hypotheses: (1) that the reinfusion of red blood cells could act like an ergogenic aid; (2) that there are harmful side-effects to the reinfusion process; and (3) that tissue hypoxia is a cause for the post-exercise increase in plasma lactic dehydrogenase (PLDH) activity. The methodology involved the induction of polycythemia in albino rats by means of the intraperitoneal injection of packed red-blood cells obtained from donor rats. Trained and untrained groups of polycythemia and control animals were subjected to either a test of maximal oxygen uptake or a period of submaximal exercise. Maximal oxygen uptake was measured by monitoring oxygen consumption with a flow-through respirometry system while the weighted rat swam to exhaustion in a cylindrical plexiglas chamber. The submaximal exercise consisted of four hours of swimming. Three control groups were maintained for the assessment of changes in the various parameters in resting animals.

Following the exercise test, venous and arterial blood samples were taken from the inferior vena cava and abdominal aorta of the experimental rats. Resting samples were taken from the animals in the three control groups. The arterial blood samples were analyzed for pH, pO_2, and pCO_2 by use of a Radiometer pH/blood gas analyzer. Spectrophotometric techniques were utilized to assay for 2,3-diphosphoglycerate (2,3-DPG), hemoglobin, and PLDH concentrations. Plasma sodium and potassium concentrations were analyzed with flame photometry. The venous sample was analyzed for only pO_2.

The significance of the difference between group means for each parameter was computed using one-way analysis of variance. The Sheffe post-hoc test was applied to data sets which demonstrated significant F-ratios (.05 level of significance). Computer techniques were used for these analyses.

The results (see Tables 1 and 2) revealed that intraperitoneal injection of packed red cells did result in statistically significant increases in hemoglobin concentration and in hematocrit readings. That is, the injected groups did become mildly polycythemic. Induction of polycythemia did not significantly effect exercise performance, as reflected by maximal oxygen uptake and work time to exhaustion. Neither were there significant variations in plasma sodium, plasma potassium, 2,3-DPG, pH or PLDH because of polycythemia induction. As expected, exhaustive exercise did cause significant alterations in pH and plasma potassium. Nonsignificant increases in PLDH due to the exercise were observed.

Weaknesses in the study included: (1) a change in method for the induction of polycythemia after the start of the experimental period; (2) excessive weight gain by the animals prior to testing; and (3) inability to collect blood during the exercise period (thus yielding the blood gas data meaningless). The first two limitations prevented collection of valuable data from the animals following submaximal exercise. Consequently, no conclusions can be made concerning the causes for the increase

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in PLDH activity following exercise.

Wtihin the limitations noted, it was concluded that the data indicate that artificial polycythemia (1) did not significantly effect exercise performance; and (2) did not result in harmful side-effects.

Table 1--Blood parameter data: group means and standard deviations

GROUP*	Hb (g%)	Hct (%)	Na (mEq/1)	K (mEq/1)	2,3-DPG (M/1)	PLDH (IU)	pH	pCO_2 (mm)	Art. pO_2 (mm)	Ven. pO_2 (mm)
B1 (n=9) Trained Not Reinfused	14.87 (.61)	52.75 (1.9)	141.1 (4.3)	4.600 (.36)	316.3 (49.3)	161.88 (51.1)	6.893 (.15)	40.31 (5.7)	112.33 (11.2)	80.8 (5.8)
B2 (n=8) Not Trained Reinfused	15.68 (.46)	55.00 (1.0)	141.2 (3.8)	4.537 (.43)	425.5 (91.2)	176.00 (21.2)	7.008 (.16)	36.33 (8.5)	86.00 (9.5)	62.0 (9.1)
B3 (n=11) Reinfused	16.02 (.66)	56.91 (3.4)	140.4 (7.5)	4.618 (.45)	361.9 (60.3)	174.28 (42.4)	6.940 (.10)	34.32 (10.9)	101.63 (14.5)	74.6 (12.)
B4 (n=8) Not Trained Not Reinfused	13.53 (.37)	52.00 (3.3)	138.2 (7.4)	4.562 (.52)	347.8 (27.8)	162.14 (33.7)	7.131 (.08)	41.21 (10.2)	96.20 (9.6)	62.8 (6.1)
C1 (n=6) Control Removal Only	14.50 (.30)	47.50 (2.2)	136.2 (2.9)	3.633 (.52)	377.8 (40.9)	95.50 (29.8)	7.462 (.05)	25.20 (6.7)	84.90 (4.3)	44.3 (14.)
C2 (n=8) Control Remov.&Reinf.	15.68 (.71)	55.50 (3.3)	142.6 (2.9)	3.887 (.28)	376.3 (65.2)	131.33 (44.9)	7.425 (.04)	43.85 (7.2)	74.14 (5.6)	51.4 (3.4)
C3 (n=9) Control Untouched	14.21 (.85)	47.00 (1.7)	137.1 (1.9)	4.137 (.28)	372.2 (27.7)	117.83 (35.1)	7.459 (.06)	31.27 (6.6)	85.05 (12.7)	52.6 (6.8)

*All data from B groups were collected after exhaustive exercise.
All data from C groups were collected with the animal at rest.

Table 2--Maximal oxygen uptake and work time to exhaustion data: group means and standard deviations

GROUP	Work Time (min)	Max VO_2 (ml/kg/min)
B1 (n=9) Trained Not Reinfused	17.11 (23.77)	37.6 (7.52)
B2 (n=8) Not Trained Reinfused	16.37 (17.67)	35.7 (4.13)
B3 (n=11) Trained Reinfused	11.36 (5.71)	38.5 (7.09)
B4 (n=8) Not Trained Not Reinfused	20.50 (17.65)	32.1 (3.85)

Reference copy: University of Oregon Science Library

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The Effects of Taurine on Ouabain Induced Arrhythmias

(Grant no. GY-10761)

Manchester College
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May 21, 1973 - August 10, 1973

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The clinical use of digitalis has been reported since 1785. Today, it is considered the single most useful drug in the treatment of heart failure and arrhythmias. Digitalis is the drug of choice for various cardiac ailments because of its inotropic and antiarrhythmetic properties. Its unwise use, however, is widely associated with digitalis intoxication considered by some to be of epidemic proportions in the United States.

A wide variety of factors influence the dosage and effectiveness of digitalis and the occurrence of digitalis toxicity. A proper dosage for a particular patient may be much smaller or much larger than the "normally" prescribed dosage. However, since therapeutic and toxic levels are nearly the same, clinical doses are difficult to determine. Other problems associated with the use of digitalis include: incorrect dispensing, accumulation of the drug in the body, and accidental poisoning. It has been estimated that anywhere from seven to 22% of those using digitalis experience toxic effects; such cases appear to be on the increase.

One of the primary indications of toxicity is the occurrence of cardiac arrhythmias. Current procedures for restoring normal cardiac rhythms include administration of propranolol, potassium salt, diphenyl-hydantoin, chelating agents, or simply waiting until the dangerous effects subside. The need for more efficacious antidotes has resulted in extensive investigation of several drugs. Taurine has shown promising results by establishing normal cardiac rhythms in dogs challenged with toxic levels of ouabain. Interest has been focussed on the use of taurine because of high concentrations found in the heart which could indicate a role in stabilizing cardiac rhythm. Cardiac glycosides, such as digitalis, are known to cause the efflux of potassium from muscle tissue, although recent experiments do not show a concomitant rise in plasma potassium concentrations. Taurine, or one of its metabolites, may prevent this efflux of potassium and, thus, offer a means of overcoming digitalis intoxication.

To investigate more fully the physiological action of taurine and its suggested role in stablizing cardiac rhythms, a structure-activity relationship study was proposed. It has been suggested that taurine and isethionic acid (ISA) may act as two members of a complex which regulates intracellular potassium concentration in some way by binding potassium ions electrostatically. To test this hypothesis, a variety of compounds were proposed which had altered functional groups, varied carbon skeletons, and fixed stereochemical relationships of the amino and sulfonic acid moieties. Although time did not allow an exhaustive study of this hypothesis, several compounds pertinent to such an investigation were synthesized.

The sulfonamide of taurine (2-aminoethanesulfonamide hydrochloride) was synthesized using an N-phthaloyl protected form of mercaptoethylamine and proceeding by oxidative chlorination of the thiol function, treatment of the sulfonyl chloride with ammonia, and finally, the removal of the phthaloyl group by hydrazinolysis. Three carbon homologues of taurine and ISA were prepared by ammonolysis and hydrolysis of γ-propane sultone, followed by a variety of work-up procedures that afforded samples of the calcium, ammonium, and sodium salts of the products. N-acetyl taurine was prepared by reacting taurine with acetic anhydride in a solution of sodium bicarbonate. Treatment of ethylene bromide with sodium sulfite in an alcohol-water solution gave 2-bromoethanesulfonate. An unsuccessful attempt to synthesize N-formyl taurine was made by treating taurine with acetic formic anhydride. Investigations into the synthesizing of compounds with fixed stereochemical relationships of the amino and sulfonic acid groups were made. This could be achieved in a molecule such as a *cis*- or *trans*-2-aminocyclopentanesulfonic acid. Six-membered ring structures were used as model compounds because of the availability of starting material.

New Zealand White rabbits of either sex were used as test animals in an attempt to investigate the *in vivo* effects of taurine on ouabain-induced arrhythmias. Ouabain was chosen because it is the fastest acting digitalis preparation and because toxic affects produced by ouabain are very similar to those produced by other digitalis-like compounds.

Animals weighing between 0.95 and 2.75 kilograms were fasted for twelve hours prior to the experiment. Intravenous injections of sodium pentobarbitol (50 mg/kg) were used to anesthesize the animals. Cardiac stability was monitored by continuously observing an oscilloscopic display of lead II. Permanent records were made of significant portions of the electrocardiogram by recording the output on a physiograph. The right femoral vein was exposed for catheterization. Infusions of drugs and withdrawal of blood samples were both accomplished at this location. One milliliter blood samples were taken every fifteen minutes for a period of 90 minutes. A control period of 15 minutes was allowed after the first sample was taken, followed by a 40-minute infusion. Blood samples were centrifuged and 0.1 ml aliquots of serum used for sodium, potassium, and glucose determinations. A Coleman flame photometer was used to determine the electrolyte concentrations, and the Worthington Biochemical Glucostat procedure was employed to determine glucose concentrations.

A series of experiments were conducted in which the following substances were administered: saline, ouabain, taurine, ouabain and taurine (simultaneously), ISA, ouabain and ISA, ouabain and 2-bromoethanesulfonic acid, ouabain and N-acetyl taurine, ouabain and mercaptoethylamine, ouabain and EDTA, and glucose. The investigations of ouabain, taurine, and ISA were the most extensive. As expected, rabbits given saline infusions maintained stable electrolyte and glucose concentrations and exhibited no cardiac arrhythmias. Rabbits given taurine or ISA exhibited similar characteristics and showed no toxic effects up to total doses of six millimoles and ten millimoles, respectively.

Administration of ouabain resulted in cardiac arrhythmias characteristic of digitalis toxicity, primarily ventricular extrasystoles. Our data, however, does not indicate a consistent trend in electrolyte or glucose fluctuations. Ouabain has been reported to produce hypoglycemia in dogs; however, the only changes observed in rabbits were increased glucose levels. To confirm that the arrhythmias observed were not caused by elevated glucose levels, glucose solutions were infused in concentrations high enough to induce hyperglycemia (serum levels of up to 200 mg%) with no concomitant arrhythmias being observed. It was also observed that a dose given on a weight per kilogram basis did not always produce consistent results. These inconsistencies were thought to be due to changes in environment, especially temperature, different ages or feeding habits, and unexplained individual differences of the animals. The larger animals, kept at lower temperatures, were able to withstand higher doses of ouabain.

When taurine or ISA was administered simultaneously with ouabain, no antiarrhythmetic activity was observed, contrary to results previously reported in dogs. Pretreatment with taurine during the control period, followed by simultaneous administration of ouabain and taurine was also ineffective. The analogues of taurine and ISA mentioned above also failed to exhibit detectable antiarrhythmic activity.

Reference copy: Funderburg Library of Manchester College

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Bone Marrow Transplants as a Possible Treatment for Sickle Cell Anemia (Grant no. GY-10782)

Benedict College
Columbia, South Carolina 29204

June 4, 1973 - August 10, 1973

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Bone marrow transplants were investigated as a possible cure for sickle cell anemia, a genetic disease affecting the formation of hemoglobin. The drug, "cytoxan" (cyclophosphamide), is known to destroy the bone marrow without immediately killing the animal, thus making possible bone marrow transplants. Since the immune response is destroyed with the destruction of the marrow, animals can accept transplants from genetically different individuals (allografts). Two different types of experiments were conducted which employed cytoxan. One series involved bone marrow transplants into genetically anemic laboratory mice, _Mus musculus_. The criterion for a successful transfer was a significant increase in the number of red blood cells. In the other series, the transplants were made between outbred deer mice, _Peromyscus maniculatus_. A hemoglobin variant, which could be observed electrophoretically, was used to indicate whether the bone marrow transplants between _Peromyscus_ were successful.

In order for the transplants to succeed, a dosage of cytoxan had to be determined which would destroy the erythrocytes without killing the animal. For _Peromyscus_, the dosage had been determined to be 650 mg/kg body weight prior to these experiments. For the laboratory mice, a dosage study was required.

Transplants were attempted on 64 anemic laboratory mice and 68% survived. Three transplants were completed in _Peromyscus_ and one survived. The survivor was shown, by hemoglobin electrophoresis, to have marrow of the donor types.

Reference copy: Benedict College Library

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Oncogenic and Mutagenic Effects of N-Nitroso Compounds on Mammalian Cells in Vitro (Grant no. GY-10754)

Massachusetts Institute of Technology
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June 4, 1973 - August 31, 1973

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The toxicity, mutagenicity, and oncogenicity of several N-nitroso compounds have been tested *in vitro*. The test systems used are in the developmental stage and were chosen for study because of their potential use as bioassay systems for routine screening of agents potentially harmful to man. N-nitroso compounds were selected for study because of the potential hazard to man as a result of the presence of these compounds and/or their precursors in foodstuffs, particularly meats. Other agents that are mutagenic and/or carcinogenic for rodent cells *in vivo* and *in vitro* have been used as control substances.

Mutagenicity has been determined by measurement of the rate of mutation to guanine-analog resistance (possibly hypoxanthine-guanine phosphoribosyltransferase deficiency) in two cell lines: 1) the V-79 adult, male, Chinese hamster (*Cricetulus griseus*) lung line, and 2) a human lymphoblast line. The latter line is unique as it is a human cell line that remains stably diploid *in vitro* and is readily mutable. We have optimized growth and cloning conditions for these cells and have reduced the duration of a mutagenicity test to one week. This lymphoblast line is the best system in existence as a bioassay system for the screening of agents potentially mutagenic to human cells *in vivo*.

Oncogenicity has been tested in an embryonic mouse fibroblast line (C3H-Cl-8), selected for its high degree of contact inhibition in the untransformed state. Oncogenic transformation was measured as the rate of the appearance of clones of dense, piled-up morphology against a confluent monolayer of normal, untransformed cells.

All results are expressed as mutants or transformants divided by percent survivors for a given dose. Percent survival (cytotoxicity) was measured as plating efficiency at a given dose for all cell lines used.

The ability of N-nitroso compounds to alter chromosomal morphology has been tested in the human lymphoblast cell line.

Results indicate that all cell lines are more sensitive to MNNG (N-methyl-N-nitroso-N'-nitroguanidine), NMU (N-nitroso-N-methylurea), and NMUT (N-nitroso-N-methylurethane) than to nitroso-amines. This supports the hypothesis that metabolic activation, probably by the liver, is necessary for full potency of nitroso-amines in vivo, whereas the former three compounds, being more unstable, can spontaneously decompose to their active forms.

Oncogenic transformation cannot be observed earlier than six to eight weeks post-treatment with the mouse C_3H line, and is not readily obtainable after treatment with N-nitroso compounds. This system, although suitable for study of oncogenic potential at the cellular level, is unsuitable for screening purposes because of the length of an assay and the systems' questionable range of sensitivity.

This work is continuing in the laboratory of Professor W.G. Thilly, Department of Nutrition and Food Science, M.I.T.

Reference copy: Library, Massachusetts Institute of Technology

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Physiological Studies and Identification of Active Components of the Steam-Volatile Distillate from Salsola kali

(Grant no. GY-10794)

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May 21, 1973 - August 3, 1973

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Previous investigation by the SOS team (GY-9564, 1972) from Southwestern State College showed that the steam-volatile substance(s) extracted from the aqueous distillate of the tumbleweed, *Salsola kali* v. tenuifolia tausch, possesses pesticidal potential. It was further believed that the component(s) responsible for this activity contained an aldehyde group. The purpose of the present investigation was to isolate and identify the active ingredient(s), to document its insecticidal properties, and to determine its physiological effects on plants and animals.

Subsequent study revealed that the three major constituents of the ether extract concentrate obtained from the steam distillate of the tumbleweed are *trans*-2-hexenal, 54%; *trans*-2-hexen-1-ol, 29%; and *cis*-1-ol, 8%. The remaining 9% consisted of an unidentified alcohol. The percentage of each component varied according to whether the original distillate had been made from the whole plant, the leaves, or the stems. The stems were shown to contain almost exclusively the trans-2-hexenal, whereas the leaves contained approximately the same percentage as that of the whole plant. The components, trans-2-hexenal and trans-2-hexen-1-ol, commonly referred to as leaf aldehyde and alcohol, are both common constituents of broad leaf plants. The leaf aldehyde has been shown to be the element responsible for the pesticidal toxicity. The other components were essentially inactive.

It was found that commercial trans-2-hexenal exhibited the following physiological effects: (1) Insecticidal toxicity for the common housefly, Musca domestica, is LD_{50}, 2.1 mg/1/300 min. This value seems to lie between the nicotine LD_{50} of 0.704 mg/1/200 min, and the xylene LD_{50} of 9.28 mg/1/400 min. (2) Inhibition of germination and/or reduction in radicle length of cucumber seeds is observed at high concentration (1275-1700 ppm.) (3) In laboratory mice, Mus musculus, no chronic physiological damage was observed; however, death did ensue when high concentrations (1120 mg/kg) were administered. (4) Bactericidal effects were noted in selected strains at low concentrations (1, 3, and 7 microliters).
Reference copy: Southwestern State College Library

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Survey of VEE Virus Occuring in Mammals of the South Texas Area
(Grant no. GY-10786)

Texas A&I University
Kingsville, Texas 78363

May 28, 1973 - August 20, 1973

Participants:

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In the summer of 1971, Venezuelan Equine Encephalomyelitis (VEE) entered Texas by way of Mexico. Extensive VEE vaccination and mosquito abatement programs were initiated in the United States; the number of equine deaths in Texas was limited to around 600.

This present study was initiated to determine whether an endemic infection of VEE had been established in the epidemic's wake. Hemagglutination-inhibition (HI) tests with VEE virus demonstrated antibodies in a Tadarida bat, Peromyscus mice, Sigmodon cotton rats, Neotoma rats, Dipodomys rats, cottontail rabbits, coyotes, purple martins, a racoon, a bobcat, a housecat, a badger, a javelina, a jack rabbit, a cow, and a roadrunner. An endemic infection of VEE was found to be occurring east of Brownsville, Texas, where 16.9% of the rodents tested had positive HI titers. Animals taken from Hidalgo County (west of Brownsville) averaged 30.5% positive, indicating sylvatic VEE activity there, also.

Participants in this study employed a technique in which ro-

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dents could be sampled by cardiac bleeding every 6 hours for up to 17 samples.

HI antibody titers were reported to horse owners whose stock had been inoculated with TC-83 vaccine.

Reference copy: Department of Biology, Texas A&I University

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A Process to Prepare Paving Materials from Wood Industry Wastes

(Grant no. GY-10781)

Arkansas State University
State University, Arkansas 72467

June 1, 1973 - August 15, 1973

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Arkansas has a large timber industry which produces approximately 23,000 tons of wood waste each month. This large quantity of waste is one of Arkansas's major disposal problems. It was felt that if a proper conversion method could be developed, this large amount of wood residue could become a new source of certain commodities presently in short supply because of dwindling reserves of energy and raw materials. It was this desire not only to dispose of these wastes but also to convert them into useful materials which prompted this research.

The investigation was conducted in two general areas by an interdisciplinary student group. One of the concerns was to undertake a biological study of the environmental considerations of open storage and open dumping of the wood waste. This consideration was important because most of Arkansas's wood waste producers simply pile their wastes in huge mounds and abandon them.

Biology students collected data on the bacteria, fungi, and anthropods which inhabit sawdust mounts. It was concluded that these organisms present no real problems for practically any disposal or conversion process which might require open storage. A matter which seemed to be a greater problem was the unsightly appearance of large, abandoned sawdust piles. A plant growth study was made of the possibility of covering these piles with green vegetation. These experiments could not be completed because time limitations did not allow the plants to grow to maturity, but preliminary results were quite promising. One interesting environmental observation was that, in some cases, the water runoff from large mounds discolored nearby streams and ponds. This observation was made late in the study and no determination was made about the actual polluting effect.

Chemistry and physics students studied thermal decomposition, or pyrolysis, as a disposal technique for sawdust. Many interesting products are reported as being made from this process, but this research was limited to a study of the heavier fractions of the products. More specifically, the possibility of producing a paving binder was considered. A binder-like material was produced, tested, and used in a test patch. Approximately four months later, the test patch is performing well but any other conclusions at this time would be premature.

Reference copy: Arkansas State University Library

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Development and Testing of Improved Methods of Tritium Detection at Atomic Facilities (Grant no. GY-10815)

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June 15, 1973 - September 7, 1973

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The purpose of this study was to develop more sophisticated tritium analysis techniques for monitoring tritium release and dispersion in the environment, and to actually test these and other radiation detection methods, by conducting a general radioecologic study of environments surrounding two nuclear facilities.

Work on improved sample processing methods for tritium analysis included the development of a vacuum distillation method not previously reported in the literature. Hydrogen isotope separation was also studied; successful results in experiments using electrolytic separation led to the routine use of this technique for sample enrichment.

A study of different tritium detection systems by liquid scintillation spectroscopy involved an extensive search for improved solvents, solutes, and wavelength shifters. Our finds include data showing that many experimental solvent systems had lower counting efficiencies and water incorporation than the commercially available solvent cocktail, Aquasol.

Work on developing new approaches for solving two problems associated with counting tritium in aqueous environmental samples is described. The first is an improved method for the incorporation of tritium from environmental water into nonpolar compounds for use as scintillator solvents, and uses organomagnesium reagents. The second is a proposed synthetic method for preparing some new alkyl-substituted phenyloxazoles having potential use as secondary fluorescent compounds in scintillation cocktails when high sensitivities to tritium are desired. Work on these compounds is still in progress.

A complex series of processing steps and counting procedures for low levels of tritium was developed during the project and submitted for publication in The International Journal of Applied Radiation and Isotopes. These techniques were used for the study of radiation in the local environment of two nuclear sites.

The two sites studied by the Yale group were the Yankee Atomic Power Plant in Rowe, Massachusetts and the site of the Dresden nuclear reactors I, II, and III in Morris, Illinois. This same site is the location of the Midwest Fuel Reprocessing Plant, now in operation.

The Rowe, Massachusetts site was studied in great depth. Rainwater samples were collected and analyzed for tritium and hard beta emitters. Results were negative in all samples. Groundwater from 52 sites was also collected from sampling wells and was tested by liquid scintillation beta particle spectroscopy. Results of this work indicated a general absence of tritium but revealed definite evidence of high-energy beta particle activity, later identified by analysis of half life, beta particle endpoint energy, and specialized radiological techniques as coming from radium-224 and daughters. Calculations show that radium levels might be higher than the Title 10 Part 20 guidelines for public exposure to radiation. This has not been confirmed by the U. S. Atomic Energy Commission as of the date of this report. However, these high radium levels undoubtedly arise naturally from the area's highly metamorphized bedrock which is rich in thorium and, therefore, there is probably little that can be done to reduce the population's exposure to soluble radium which enters the well water.

Tritium studies of the Rowe, Massachusetts area showed a widely varied concentration of tritium in plant life. The cause of this variation appears to be due in part to different levels of ambient tritium being present at the various sites, but also might be due to the differences of tritium uptake by different species.

River sediment radioactivity in the Deerfield River in Massachusetts exhibited little evidence of increased activity due to low-level releases from the Yankee Atomic Power Plant. The reading of abnormally high levels of thorium-232 in the sediment constitutes additional evidence that, indeed, it is Ra-224 (a daughter of thorium-232) being detected in groundwater.

Much of the data obtained from the Morris, Illinois site have not been fully analyzed as of the writing of this report. River sediment analysis by scintillation gamma-ray spectroscopy has demonstrated the existence of only background levels above and below the site of the Dresden power stations. Groundwater samples have shown no traces of tritium or other sources of extraneous radioactivity, and rainwater analysis has, similarly, shown no radiation content above natural background.

Data concerning tritium in plant life are still being processed, and analysis of the available results is not feasible. One finding, however, is that the levels are almost uniformly lower than those registered in the forest environment of Rowe, Massachusetts. The plants in the grasslands environment either incorporate less tritium or, more likely, the ambient levels of tritium are lower and, hence, the equilibrium uptake levels in the local plant life are correspondingly lower.

Since the Mid-West Fuel Reprocessing Plant will be one of the largest (if not the largest) donor of man-made tritium to the environment, the knowledge of natural tritium levels in the local environment will be extremely useful as a pre-operational background study against which to compare tritium monitoring after the plant has begun operation.

Reference copy: Kline Biology Tower Science Library of Yale University

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Detecting Aflatoxin-Producing Strains of Aspergillus flavus in Soil and Corn Samples (Grant no. GY-10813)

Morehead State University
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April 1, 1973 - July 27, 1973

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The objectives of phase I of this study were to detect and isolate *Aspergillus flavus* from samples of soil found in corn fields, crib corn, and silage from selected counties in Eastern and Western Kentucky. Those counties included were Rowan, Fleming, Carter, Trigg, and Christian. Samples from these counties were collected between May 14 and May 31, 1973.

The samples (97) were collected at random locations in cornfields at depths between 0 and 4 inches. They were then labeled, stored (0-10^{o}C), and later assayed on a modified Bell and Crawford medium composed of peptone, glucose, chlorotetracycline, HCl, streptomucin sulfate, and mineral salts (KH_2PO4 monobasic and $MgSO_4 . 7H_2O$), supplemented with 3% NaCl plus 2 ppm Botran (2.6-dichloro-4-nitroaniline).

The samples were plated into the above media using the dilution plate count technique. Ten grams (dry wt.) of soil were plated at 10^{-1} and 10^{-2} dilutions. A one-million aliquot of each dilution was placed on each plate of the selective media.

A. flavus was found in the soil samples collected from the following counties:

a) Rowan (0-16.7)
b) Fleming (0-5.97)
c) Carter (0-4.2)
d) Trigg (1.3-43.6)*
e) Christian (1.6-258.0)*

The figures listed after each county represent the population range (propagules/gram of air dry soil) detected in each county surveyed. A. flavus was also detected in 13 out of 17 cribcorn samples as in 8 out of 10 silage samples.

In phase II, selected strains of Aspergillus flavus, originally isolated from soil, cribcorn, and silage using the modified Bell and Crawford technique, were maintained on YES agar slants (20% sucrose, 2% yeast extract, and 2% agar). At various intervals, the isolates were transferred to YES broth to determine the capability of each strain to produce aflatoxins B_1 and G_1. N. D. Davis, U. L. Diener and D. W. Eldridge have shown that maximum yields of B_1 and G_1 by Aspergillus flavus may be obtained by using the YES broth. Transfers were made to 100 milliliters of YES broth in one liter Erlenmeyer flasks and allowed to incubate 6-8 days at 25°C before extractions were made.

Of the 130 isolates of A. flavus that were obtained from soil, cribcorn, and silage samples, in different corn fields in Trigg, Christian, Fleming, and Rowan counties, 43 were transferred to the

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*It appears that Christian and Trigg county soils may be considered as high risk areas.

YES broth. Toxins were extracted from 35 of these cultures by the procedure described by Pons, Cucullu, Lee, Robertson, Franz, and Goldblatt in Determination of Aflatoxins in Agricultural Products: Use of Aqueous Acetone for Extraction. All extracts yielded fluorescent compounds when excited by ultraviolet light.

The same extraction procedure was used on 23 50-gram (dry wt.) samples of corn grain (16) and silage (7) from the above mentioned counties. Six corn samples contained aflatoxins, while two silage samples contained detectable amounts of aflatoxins. Residual pigmentation which might influence the TLC results was removed with diethyl ether in a chromatographic column.

Visual comparisons of standard toxin (obtained from Dr. Leo Goldblatt) of known dilutions, with sample extraction on TLC plates, were made to determine amounts of fluorescent compounds present in the extracts. The toxicity of the fluorescent compounds extracted was determined by a duckling bioassay.

In phase III, a standard duckling bioassay was conducted in an attempt to determine the toxicity levels of aflatoxin-producing strains of *A. flavus*. Ninety-nine ducklings were employed in this test, and were divided into eight test groups. Group I, subdivided into subgroups A, B, C, D, and E, received dosages of standard aflatoxin (B_1 and G_1, B_2 and G_2) supplied by Dr. Leo Goldblatt, USDA, ARS, New Orleans, Louisiana. The dosage, determined by .4 ug/kg body weight, LD_{50}, was administered in concentrations of 13 ug, 9.2 ug, 5.8 ug, and 3.2 ug to subgroups A, B, C, D, and E, respectively. Group II and III were fed suspect aflatoxin-containing corn and silage. Group IV was to have been dosed with silage extracts, but was dropped from the experiment due to insufficient aflatoxin extract. Group V was dosed with propylene glycol (PG) to determine if any abnormalities were due to PG. Group VI served as a control group and was fed aflatoxin-free corn. Group VII received aflatoxin-containing extracts collected from YES media in which isolates of _A_. _flavus_ from Christian County, Kentucky, had been grown. This group was divided into subgroups A, B, C, D, with dosages (ug/ml) being 1,560 ug, 1,075 ug, 135 ug and 1545 ug, respectively. Group VIII was a control group maintained on corn mash determined as being aflatoxin-free and fed as a diet supplement to the other test birds.

After seven days, the livers were removed, prepared in paraffin blocks, sectioned on a microtome, and slides prepared. The slides were stained with eosin and hematoxylin and examined for abnormalities in cell structure. The findings indicate a necrosis of the duckling's liver cells known as lytic necrosis. At the end of seven days, it was seen that several ducklings experienced a loss of weight, appetite, and had become lethargic.

Western Kentucky, which is the main corn-producing area in Kentucky, had a much higher population of _Aspergillus_ _flavus_ in the soil, cribcorn, and silage samples than that found in Eastern Kentucky. Cribcorn and silage samples collected from both sections of the state did yield detectable amounts of aflatoxins, however. Thus, it is quite evident that this fungus is a ubiquitous organism and, therefore, the toxin-production by this fungus is a potential threat to livestock which feeds upon contaminated cribcorn and silage during the winter months.

Reference copy: Library of Morehead State University

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Information Level Studies Related to Venereal Diseases in South Dakota (Grant no. GY-10808)

Northern State College
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June 1, 1973 - August 10, 1973

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The purpose of this project was to gather information to be used by the State Department of Health and the Indian Health Service in South Dakota for an evaluation of their current programs and for suggesting educational programs which might help meet current needs. The project was also intended to guide the formulation of planned programs for venereal disease education at the host institution with special emphasis on the preparation of teachers in this subject.

The survey design incorporated a multi-stage sampling system with several stratifications. The plan involved a simple random sampling procedure with replacement in selecting counties from several geographic and population categories within the State. Systematic random sampling was employed for the selection of names in the final stage.

In each of the counties which were selected at the first sampling stage, the population was divided between rural and urban areas. Within these two categories, the population was split into a 15-19 year-old age group and a 20 and older age group. It was after this stage that names were actually drawn.

Several sampling frames were used. In selecting names for the former age group, school census information was used. This provided a complete listing of all persons of this age in each county. For the latter group, three sampling frames were used: county personal property lists, voter registration lists, and city or county directories.

The survey used a target of 2.43% of the population in each area to be interviewed. An extra pool of names was drawn in each county as replacements for those who had moved, died, or could not be located. The interviews were conducted in person, using a questionnaire and pre-coded response sheet. This information was then transferred to punch cards and processed by computer.

The project planned to interview 3,935 people in South Dakota. Of this number, 3601 people were located by interviewers and 3194 interviews completed. More women than men refused to participate in the survey. Most who refused to participate were also over

40 years old. People who refused to participate also tended to live in poorer housing.

Four scales were used to reduce the data for analytical purposes. The scales were based on answers to questions concerning gonorrhea, syphilis, general knowledge, and a composite score of the means of the other scales. To compare the awareness and educational levels of different groups, the possible scores were grouped into low awareness, average awareness, and high awareness for the scales. These categories do not indicate the actual awareness _per se_, but are used for comparative purposes.

Scores on the scales indicating awareness of the different aspects tended to increase with educational level; people between the ages of 20 and 35 also tended to be more aware than people in other categories. People who said that they were most likely to get information about venereal disease from friends and the radio tended to do poorly on the scales, and people who listed school programs and magazines tended to score higher.

The following tables show the percentage in each of the categories who scored in the _high_ awareness level for the gonorrhea, syphilis, and general information scales.

EDUCATIONAL	LEVEL					
	Grades 0-8	9-12	Completed High Sch.	Some College	Completed College	Graduate
gonorrhea)	5%	9	13	17	20	26
syphilis)	6	7	15	20	30	36
general)	3	9	13	22	29	46

AGE	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-50	60+
(gonorrhea)	49%	61	57	57	52	54	49	42	26
(syphilis)	13	21	20	16	19	19	17	14	10
(general)	--	1	2	2	2	1	1	--	--

SOURCE OF INFORMATION

	Friends	Newspapers	Radio	T.V.	School	Pamphlets	Magazines	Othe
(gonorrhea)	7	12	6	13	15	13	16	18
(syphilis)	8	18	13	10	19	16	17	18
(general)	4	12	8	11	20	17	18	19

Other analyses indicated that veterans did significantly better than non-veterans on the survey. Approximately 37% of the persons surveyed had had a sex education class of some type; these individuals did better than those who had not had a class. It was also shown that men living in positively-rated housing tended to do best on the survey, with women in positively-ranked housing and men in negatively-ranked housing closely behind; women in negatively-rated housing tended to do worst. These last results, concerning housing, used a non-standard analysis approach and so should be regarded with some caution.

Further work is being done to determine the nature of the distribution of scores for the scales and the best statistical approach to be used in future analysis.

Reference copy: Northern State College Library

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A Correlation of Toxicity with Heavy Metal Accumulation in Tissue, using Proton Induced X-Ray Emission Spectroscopy

(Grant no. GY-10772)

William Marsh Rice University
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May 29, 1973 - August 10, 1973

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An attempt was made to correlate the tissue accumulation of heavy metals with a lethal toxic response in three aquatic species. This correlation, if demonstrated, could be used to generate a relative susceptibility index for the tested organisms. In addition, the feasibility of determining tissue concentrations of heavy metals, using proton-induced X-ray emission spectroscropy, was examined.

Biological data on toxicity were generated for three organisms; rainbow trout (Salmo gairdneri), fathead minnows (Pimephales promelas), and brown shrimp (Penaeus sp.). These organisms were exposed to various aqueous concentrations of lead, mercury, copper, zinc, and a bimetallic zinc:copper mixture in a ratio of 6:1. Each of these five metal groups were used in aqueous concentrations of 10, 1, .1 and .01 ppm. In addition, each metal concentration combination was examined at two temperature ranges: one range being near the species optimum, and the other producing temperature stress.

Each test was run for 96 hours under controlled conditions. Temperature, pH, and metal concentration were checked periodically. Test containers were examined at least hourly for mortalities. Upon death, the organism was extracted from the test container, the survival time noted, and the animal weighed. The organism was then prepared for heavy metal analysis using an ultrasonic probe, and was doped with the analytical standard. Survival times were calculated for all aquatic forms and were subjected to analysis to determine average and mean values.

Physical methods involved the use of the Rice University Van de Graaf accelerator. The technique used was proton-induced X-ray emission spectroscropy. With this method, it is possible to determine the concentration of all elements in a specific sample with an atomic number greater than twenty. The feasibility of the application of this technique to tissue sampling was under study. To make this determination, reproducibility studies were made on biological samples and on seawater.

In addition, the spectroscropy technique was used to analyze the tissue samples from the toxicity determinations. Each tissue sample was refrigerated in glass scintillation bottles until target preparation. Each target was then subjected to the proton-beam and the emitted X-rays analyzed with the aid of a computer. These analyses gave the data on the concentration of each metal in the tissue.

Results for the reproducibility of the spectroscropy technique show that the technique is valid. Tissue samples can be analyzed at the 1 ppm level with an accuracy of ±15%. In addition, the technique analyzes simultaneously for all heavy metals.

The toxicity analyses failed to show the hypothesized correlation between lethal dose of toxic metal and the accumulation of that toxin in the tissues.

It was concluded that X-ray emission spectroscopy was a useful and powerful tool for tissue analysis. However, more knowledge of the specific mode of toxic action is needed before any conclusions can be made concerning the toxic role of organic toxic accumulation.

Reference copy: William Marsh Rice University Library

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Bromolipids in Foodstuffs (Grant no. GY-10807)

Vanderbilt University
Nashville, Tennessee 37203

May 15, 1973 - August 9, 1973

Participants:

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Brominated vegetable oils are synthetic food additives found in some fruit-flavored soft drinks, added to keep flavoring oils in suspension. These studies were undertaken to evaluate the fate of these substances in the body.

Brominated vegetable oils are produced by the addition of molecular bromine to a solution of vegetable oil, resulting in the bromination across double bonds of unsaturated fatty acids. To detect the occurrence of brominated vegetable oil and to measure the amount of the compound in foodstuffs, a highly sensitive assay utilizing gas chromatography, coupled with electron capture detection, was developed in our laboratory. This material is a mixture of triglycerides with long-chain fatty acids and their brominated derivatives. The predominant species are 9,10-dibromostearic acid and 9,10,12,13-tetrabromostearic acid, the bromination products of oleic acid and linoleic acid.

Quantitative ether extracts of 34 soft drinks available in the markets of Nashville were analyzed for bromolipids. Thirteen of these products were found to contain bromolipids in a concentration of about 15 p.p.m., the upper limit permitted by the United States Food and Drug Administration. Only four of the 13 listed bromolipids on their labels.

Adult male Wistar rats (200-250 grams) were allowed to feed *ad libitum* and supplemented with daily doses of brominated vegetable oil administered with a stomach tube. There were three groups of rat: 1) a control group receiving only pure cottonseed oil, 1200 mg/kg body weight; 2) a group receiving brominated cottonseed oil, 400 mg/kg body weight; and 3) a group receiving brominated cottonseed oil, 1200 mg/kg body weight. The livers of the rats were studied histologically after 15 days. Sudan II was used to stain for lipid droplets and the sections were examined by light microscopy. Only small-sized lipid droplets are observable in the sections of liver from control rats and those fed the lower dosage of bromolipids The livers of rats receiving the higher dosage of bromolipids is distinctly abnormal, with many large lipid droplets observable. These histological observations are in agreement with Munro *et al*. (*Food and Cosmetic Toxicology* *7*, 25, 1969).

We also prepared purified cell fractions from the livers and studied the accumulation of bromolipids in mitochondria and microsomes. Fatty acid oxidation occurs exclusively in the mitochondria. The accumulation of bromolipids in mitochondria and microsomes of rats continuously fed bromolipids makes it clear that bromolipids are incorporated into these membranous fractions of the liver to the extent of six to nine percent.

In view of this compound's possible toxic effect, it was important to find out if brominated fatty acids were being cleared from the membranes or if accumulation was occurring. Young rats were given a single dose of isotopically-labelled stearic or oleic acid together with dibromostearic acid. The rate of turnover of these fatty acids from the phospholipic fraction of the membrane was measured by gas chromatography and scintillation counting. In this way, the turnover of dibromostearic acid and a natural fatty acid could be followed in the same animal. The half-life of 9, 10-dibromostearic acid is comparable to the half-life of oleic and stearic acids; both average close to 2 days.

To characterize the purity of the mitochondrial and microsomal preparations, the specific activities of certain marker enzymes were assayed. The enzymes were DPNH-cytochrome c reductase, rotenone-insensitive DPNH-cytochrome c reductase, and succinate-cytochrome c reductase. The activity rates of these enzymes are well characterized with respect to the subcellular components, and can give a good indication of contamination by other subcellular organelles. However, following the rates of these enzymes with respect to bromolipid consumption became the significant part of the experiment.

A large decrease in the enzymatic activity of all three enzymes was observed in both the low dosage and high dosage continuous feeding rats. It must be pointed out that the control rats fed pure cottonseed oil exhibited the same sort of enzymatic behavior. Following the specific activity of these marker enzymes in the turnover experiment proved even more fascinating. The rates dropped initially. By the fourth day, they had started to recover, regaining most, if not all, their normal function by 14 days. These data imply that one of the compounds fed has an inhibitory effect on these oxidative enzymes, and that with discontinued use, the normal activity recovers with time.

The next phase of our studies deals with the effect of brominated fatty acids on specific enzymes systems. Stearic acid, a normal fatty acid, is oxidized by isolated liver mitochondria. In contrast, brominated fatty acids are not metabolized. Further, the oxidation of the normal fatty acid by the mitochondria is inhibited by high concentrations of brominated fatty acids.

Another fate of stearic acid is that it can be desaturated to form oleic acid by microsomes. This desaturase system is an essential step in the biosynthesis of oleic acid in selectively removing hydrogens from the 9,10 positions to yield oleate. The straightforward results of this experiment show that 9,10-dibromostearic acid is not utilized as a substrate for the desaturase system, nor does it inhibit the desaturation of stearic acid.

Because of the inadequacy of previously compiled information on soft drink consumption, a survey of metropolitan Nashville was carried out to identify consumers of brominated vegetable oil-containing drinks and to ascertain the amount consumed. Data

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were compiled by sex, income, race, and age with the use of a computer program. Bromolipid-containing soft drinks make up 4% of the total soft drinks sold, with the average consumer ingesting about 13-20 mg of bromolipid per week. An individual drinking the contents of four-12 ounce bottles would consume as much as 20 mg brominated vegetable per day (140 mg/week). Reference copy: Vanderbilt University Library

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Investigation of the Transfer and Accumulation of Cadmium in Biological Systems (Grant no. GY-10806)

Purdue University
Lafayette, Indiana 47907

May 14, 1973 - July 27, 1973

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Cadmium is a toxic, heavy metal, similar to zinc in its atomic size and valence, owing its toxic properties principally to its behavior as an antimetabolite of zinc, competing with zinc for protein binding sites. Cadmium has 3000 times the affinity for proteins that zinc has and irreversibly binds to them, inactivating important enzymes which require zinc for their activity.

Cadmium can enter the body from the air (by way of the lungs, causing damage to the lungs, as in emphysema) and from food and water (absorbed from the gastrointestinal tract along with other metals, mainly from food, causing kidney and liver damage).

Pathologic conditions caused by cadmium include itai-itai disease (a severe degenerative bone disease causing soft, brittle bones), kidney disease, and shortened life span. Cadmium has also been implicated in hypertension, cancer, spontaneous abortions and heart disease.

Cadmium enters the air from metal refining and smelting operations, particularly from zinc purification, but also from the burning of soft coal in which cadmium is a trace contaminant, and from steel manufacturing operations.

Cadium gets into water by being washed out of the air by rain, by the dumping of cadmium electroplating solutions into streams, and from agriculture runoff from fields treated with cadmium-containing fertilizers (phosphate and superphosphate) and fungicides.

Cadmium enters food by being transferred from one level of the food chain to the next. Plants take up the cadmium from water and concentrate it in their tissues. These plants are eaten by animals and absorbed by the gastrointestinal tract. The animals are then used as a food source by man who receives the accumulated cadmium. Food has been found to be the greatest source of cadmium for man.

We investigated cadmium uptake and transfer from each level of an aquatic food chain to the next with the use of a radiotracer technique. The radionuclide ^{115m}Cd was introduced into water in which Chlorella sp. (a single cellular green algae) was growing. The uptake of the cadmium by algae was found to be 61.9%, with a concentration factor on a gram to gram comparison of 184.3 over the water level of cadmium. From the algae to the first consumers (tadpoles and river clams), the uptake was found to be 0.70% of the amount of cadmium originally in the water or a concentration of 6.27 times as much per gram as in the water originally. The tadpoles and river clams were then fed to secondary consumers (fish and crayfish). The largest transfer occurred in crayfish fed clam meat which occasioned an overall transfer of 0.02% of the cadmium initially present in the water into the secondary consumer. Although this transfer percent is very low, it is still greater than would be found in animals that ate food which had not been exposed to the cadmium. Zinc was studied in a similar fashion, giving the same 0.02% transfer from the water to the secondary consumers. The interaction of zinc was studied using a molar ratio of 2.480M cadmium: 1M zinc. The uptake of the cadmium and of the zinc was greatly increased in the algae but the overall transfer to the secondary consumers was the same.

The distribution of cadmium in the body was examined, using the rat as an animal model. We attempted to determine whether the distribution of cadmium among the liver, kidney, pancreas, spleen, stomach, small intestines, caecum, heart and lung differed (with length of time) from the intraperitoneal injection of the cadmium to the time of sacrifice. The sacrifice times chosen were 6, 12, 24, 36, 48 or 72 hours after administration. The greatest concentrators of cadmium were the liver, kidney, pancreas, and spleen, in that order. The concentration of cadmium in these organs did not change with time and had the same levels of cadmium at 6 hours as at 72 hours.

We studied the effect of the dose of cadmium given and found that with increasing dose (0.5, 1.0, 1.5, 2.0 and 2.5 mg/kg cadmium) the liver showed a decreasing uptake with increasing dose, while the other organs remained the same except for the lung which increased its uptake with increasing dose.

The liver makes a specific protein in response to cadmium, metallothionine, which can strongly bind cadmium and prevent its toxic effects. In both of the above studies, we could detect the presence of this protein and measure the amount produced with time and with different doses. We examined the effect of this protein on the distribution of cadmium in the rat by inhibiting protein synthesis with cycloheximide (which inhibits protein synthesis) and actinomycin-D (which binds to the DNA and prevents the production of RNA which is necessary for the production of protein). We found that cycloheximide prevented the synthesis of metallothionine, while actinomycin-D did not. The organ distribution was altered in the amount of cadmium taken up by the various organs studied, but that the rank of the organ (in its ability to concentrate the cadmium) did not change and remained as liver, kidney, pancreas and spleen in decreasing order of organ concentration. We have purified and quantified the amount of metallothionine produced with varying dose and time and have detected its production as early as 6 hours after exposure to cadmium.

The cadmium levels in children's teeth in areas with known cadmium exposure and from areas having little cadmium exposure were compared. Less than 0.05 ppm in children's teeth (the limit of detection of our equipment) were found.

We studied the uptake of cadmium from soil by earthworms and found that the worms will concentrate the cadmium above the level found in the soil. These worm levels vary directly with the soil level of cadmium. Earthworms collected at various distances from a source of cadmium emission were investigated; the levels in earthworms seem to decrease with increasing distance from the source.

Reference copy: Library, School of Pharmacy, Purdue University

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Biochemical and Cytogenetic Effects of Pesticides on Human Cells in Vitro (Grant no. GY-10765)

University of Maryland
College Park, Maryland 20742

May 27, 1973 - August 19, 1973

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Two carbamate pesticides, ziram (zinc dimethyldithiocarbamate) and carbaryl (1-napthyl-N-methylcarbamate), and one organophosphorous pesticide, DDVP (phosphoric acid 2,2 dichlorovinyl dimethylester) were examined for their toxic and mutagenic effects on human cells in culture. Low passage human embryonic lung cells, a serial line of foreskin fibroblasts, and a human lymphoblastoid line (RPMI 1788) were utilized. TD_{50} determinations demonstrated that ziram was the most toxic compound (by a factor of 100), followed in order by DDVP and carbaryl. Growth curves also reflected this differential toxicity for ziram. The lymphoblastoid line proved to be approximately five times more sensitive to ziram than the fibroblastic cultures. The mutagenic potential of the compounds was examined using the incidence of induction of chromosome abnormalities as an index of mutagenicity. Carbaryl did not induce abnormalities and only one case of an abnormality was noted with DDVP. Ziram at .5 ug/ml resulted in a 6% incidence of endoreduplication and in one case, a symmetrical non-homologous translocation. Methyl methanesulfonate, employed as a positive control, caused both breaks and rearrangements (symmetrical homologous and non-homologous). Inhibition of DNA, RNA, and protein synthesis by ziram was monitored by following the incorporation of appropriate tritiated precursors into TCA precipitable material. Severe inhibition of the synthesis of all three macromolecular components was observed in lung and skin cells at a level of .5 ug/ml and in lymphocytes at a level of .1 ug/ml; inhibition was 80%-90% at these levels.

Reference copy: University of Maryland Library

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Mutagenic Effects of Food Additives and Their Metabolites, using Host-Mediated Assay (Grant no. GY-10774)

Reed College
Portland, Oregon 97202

May 28, 1973 - August 17, 1973

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Peter J. Russell, Faculty Advisor

The objectives of this project were to determine the mutagenic effects of various food additives and/or their unspecified metabolites on eukaryotic cells, using a host-mediated assay. Suspensions of the vegetative conidia of Neurospora crassa were either directly exposed to the additives or placed in diffusion chambers and implanted in the peritoneal cavity of rats on controlled diets containing specified concentrations of additives. Mutation frequencies are scored on colonies of an induced Neurospora heterokaryon as forward mutation in the ad-3 region (comprising one to two loci). The chemicals tested were sodium benzoate, polysorbate 80, butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), caffeine, monosodium glutamate, vanillin, calcium propionate, and sodium nitrite. Certain of these additives were chosen for radiochemical experiments to determine, in the host-mediated assay, whether they reached the peritoneal cavity in appreciable amounts, and to discover whether they or their metabolites accumulated in specific organs.

The host-mediated assay was shown to be capable of detecting the effect of microbial mutagens in compounds which remain, or become physiologically active, after administration to and metabolism by a mammalian host. All of the food additives tested in vivo and most tested in vitro caused a much higher rate of mutation than that found in controls. In a few cases the death rate of the in vitro treatment obscured meaningful mutation frequencies. All additives caused a much higher mutation rate than did the controls in vivo. Such an assay, however, does not implicate the specific deleterious agent within the host. The evidence obtained, on the simplest level, is merely an indication of the effect of a substance or its metabolic and/or anabolic products.

Reference copy: c/o Peter J. Russell, Reed College

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Functions of Prostaglandins in Reproduction, Parturition and Infertility (Grant no. GY-10793)

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May 28, 1973 - August 17, 1973

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The purpose of this study was to investigate the role of prostaglandin $F_{2\alpha}$ ($PGF_{2\alpha}$) in the process of parturition in the rat. Since $PGF_{2\alpha}$ is known to have luteolytic properties, our experiments were designed to determine whether the physiological role of $PGF_{2\alpha}$ is to function as a "luteolysin" at term. We observed that:

1) Treatment of both intact and hypophysectomized rats in late pregnancy (days 20 and 21) with $PGF_{2\alpha}$ results in a rapid fall in plasma progesterone concentrations, determined by radioimmunoassay, and premature delivery of the conceptuses. Administration of the synthetic progestin, Depoprovera, did not prevent the prostaglandin-induced fall in progesterone levels, but premature delivery was adverted. Thus, $PGF_{2\alpha}$ treatment appears to cause prematurity by reducing blood progesterone levels.

2) Indomethacin, a potent inhibitor of prostaglandin biosynthesis, delayed the onset of parturition by 20 hours when administered to rats starting on day 19 of gestation. However, animals receiving both indomethacin and $PGF_{2\alpha}$ delivered at the same time as the control animals.

3) Treatment of both intact and hypophysectomized rats in

late pregnancy with indomethacin delayed the fall in plasma progesterone levels which normally occurs between days 20 and 23 of pregnancy. Concomitant $PGF_{2\alpha}$ treatment caused progestin levels to fall at the same rate as in control animals.

4) Administration of a specific antiserum to $PGF_{2\alpha}$ to rats in late pregnancy delayed the onset of delivery, but injections of rabbit anti-goat serum had no effect on the time of parturition.

Since the corpora lutea appear to be the major source of progesterone during pregnancy in the rat, $PGF_{2\alpha}$ seems to affect the progesterone-producing capacity of these structures. We conclude that one of the physiological roles of $PGF_{2\alpha}$ is to induce luteolysis and thereby cause a fall in progesterone levels which then leads to parturition. The action of $PGF_{2\alpha}$ does not appear to be mediated by the hypothalmus or pituitary, since $PGF_{2\alpha}$ induced premature delivery in both intact and hypophysectomized animals, and indomethacin caused a delay in the onset of parturition in both intact and hypophysectomized rats.

Reference copy: c/o Dr. J. F. Strauss, Department of Reproductive Biology, University of Pennsylvania School of Medicine

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A Study of Transmission of Selenium Across the Placental Membrane

(Grant no. GY-10743)

Reed College
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May 21, 1973 - August 10, 1973

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Selenium (atomic number 34, atomic weight 79) occurs naturally in the earth's crust at a concentration of 0.09 micrograms/gram and is found in many mineral deposits in the arid and semi-arid Midwestern United States. It is also found in high concentrations in fossil fuels (8 μg/g) and in volcanic rock (120 μg/g).

Selenium is used heavily in industry in the United States for the manufacture of glass, pigments and electrical equipment. It is estimated that nine hundred tons of selenium is released annually into the atmosphere (David, 1972). Although essential for life in trace amounts, selenium is very toxic in concentrations of μg/g (Rosenfeld and Beath, 1964). Because of the recent work showing that methyl and ethyl mercury can be transported across the placental membrane and concentrated by the fetus, causing severe birth defects, we attempted to study the transmission of selenium across the placenta.

Rats were used in this study because of the similarity between the rat and the human placenta and because of the relatively low animal cost.

The air above Portland, Oregon was sampled for selenium, but this part of the project had to be abandoned because of equipment failure.

Selenium was detected by neutron activation analysis, using the Reed College Nuclear Reactor Facility, and gamma-ray spectroscopy, using a lithium drifted germanium detector - Ge(Li) - coupled to a 4096 multichannel analyzer and computer analysis. Rats were injected with selenium and allowed to inhale selenium.

Selenium was not detected with any consistency in each individual rat. Only 28.3% of the pups from the mothers who had received injected selenium had detectable amounts of selenium. This is a greater number than those for the rats that inhaled selenium (36%) and for the control rats (54.5%). Liver samples from the mothers had an even smaller frequency of detectable selenium (24.3%), but selenium was found in 80.5% of kidney samples.

The concentration of selenium in the pups where selenium was determined did not significantly differ, whether the mothers were injected with selenium (0.12 ± 0.050 μg/g), inhaled selenium (0.78 ± 0.022 g/g), or were controls (0.071 ± 0.025 μg/g) because of the large standard deviation.

The value for the average content of selenium in the livers of the injected rats (2.0 ± 1.5 μg/g) does seem to be greater than the average of the control livers (0.059 μg/g). However, the large fluctuations in standard deviation of the first value and the uncertainty due to the small sample size of the latter value makes this observation rather tenuous.

The value for the average content of selenium in the kidneys

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of the injected rats (16.68 ± 3.09 μg/g) is the best value obtained. This, which is significantly greater than the control value (4.4 μg/g), is the best indication of response in this experiment.

The method was checked with a sample of NBS Bovine Liver containing a certified amount of selenium. Problems with the method of of analysis gave a sample size that was too small, and about at the limit of detection for the particular method used.

The data do indicate, however, that selenium probably does not cross the placental membrane to any great extent. However, even if it did and we could not detect it, selenium certainly is not concentrated in the fetus to the extent that it is concentrated in the liver or kidney.

Reference copy: Chemistry Departmental Office, Reed College

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Soluble Dithizones as Antidotes for Heavy Metal Poisoning in Test Animals (Grant no. GY-10768)

The Johns Hopkins University
Baltimore, Maryland 21218

June 5, 1973 - August 26, 1973

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Cadmium is highly poisonous, grossly under-investigated as an environmental contaminant, but widely dispersed. As a natural component of soils and water, it is present only in very low concentrations, but its industrial uses are expanding tremendously. In 1957, Scandanavian toxicologists declared emphatically that cadmium probably has more lethal possibilities than any other metal, an assessment which appears to have been largely ignored in terms of the potential public health hazards.

One very important aspect of cadmium is its potent role in the production of hypertension, and hence, its importance to cardiac disease. Schroeder (1969) showed that, in experimental animals, there is a relationship between cadmium-induced hypertension and its reduction by the administration of a zinc-chelating agent; it was from this evidence that our plans to explore zinc dithizonates as antidotes against cadmium toxicity.

The protocol for this study called for the treating of random-bred mice, made hypertensive with cadmium, with lipid and water-soluble derivatives of dithizone, administered through various routes (e.g., oral, intraperitoneal). Other heavy metal toxicities were also examined.

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Section III.

General Environmental Studies

Papers from the New Mexico Institute of Mining and Technology, Mercyhurst College, Michigan State University, Amherst College, MacMurray College, Swarthmore College, Virginia Polytechnic Institute and State University, University of Illinois at Urbana, Providence College, University of Michigan, New Hampshire College, Manhattan College, Bethany College, University of California at San Diego (2), University of Montana, University of Southern Mississippi, University of Nebraska, University of Hawaii, University of Wisconsin at Stevens Point, Beaver College, Sonoma State College, Auburn University, San Diego State University, University of Arizona, and Western Washington State College.

Seeding Trials and Soil Analysis in the Midway Watershed Area

(Grant no. GY-10789)

New Mexico Institute of Mining and Technology
Socorro, New Mexico 87801

June 1, 1973 - August 22, 1973

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The Midway Watershed Area is five miles north of Socorro, New Mexico, on the west side of the Rio Grande Valley. Elevations range from 7200 feet in the Lemitar Mountains to 4700 feet in the Rio Grande Valley. Vegetation is predominantly creosotebush (Larrea tridentata) and annual desert weeds. Small, intense thundershowers, common to the area, often produce excessive runoff and flood damage. The grass species present will not support a healthy grazing industry.

Muller, et al. (1972, SOS Grant GY-9688) selected and fenced two study areas in the watershed. Site One is in a grass-shrub area, and Site Two is in creosotebush. Sites were divided into test plots, each fifty-feet square. Plots were selected from each site, cleared of vegetation, reseeded, and mulched with either bark chips, fly ash, or straw. Some plots were also protected with a rodent fence of window screening stretched around their perimeters.

An additional two test sites were constructed by this year's project. Site One Prime is immediately adjacent to Site One, and Site Three is in a creosotebush/non-creosotebush transition zone. All of this year's plots were protected from rodents by fencing. Sewage sludge, fly ash, straw, and combinations of two of these were applied to selected, cleared plots. Cleared plots were also reseeded with grasses and clover.

Selected plots from all sites were analyzed chemically for major plant nutrients, common cations, and common anions. It was discovered last year that Site Two has seven times the calcium ion concentration as Site One. There were no significant changes in the soil chemistry of plots mulched last year. Several creosotebush and non-creosotebush areas in the watershed were also analyzed. Most creosotebush areas in the watershed area showed higher calcium concentrations, but this was not always true.

Microbial studies made of last year's test plots revealed that mulched plots, especially straw plots, had higher microbial activities. It was also shown that mulching may reduce denitrification rates.

Of the mulches and treatments used this year, greenhouse studies indicated that treated sewage sludge has the most potential as a mulch. Rodent studies were conducted which suggest that non-creosotebush areas have higher rodent populations.

One year after seeding, vegetation remains sparse on Site Two.

Alkali Sacaton and Boer Lovegrass are the seeded species which did best, but they are not very abundant.

Site One plots responded well to seeding, and are developing a moderate cover of Threeawns (*Aristida sp.*), Fluffgrass (*Tridens pulchellus*), and Plaintain (*Plantago purshi*). Grama grasses (*Bouteloua sp.*) and Sand Dropseed (*Sporobolus crytandrus*) are also present. Plots which were protected from rodents had roughly 25% more cover than unprotected plots at the end of this year's growing season. Fly ash plots did better than other plots after a dry spring. However, all mulched plots fared the same after a long autumn dry spell. All mulched plots finished the season with roughly 20% more cover than unmulched plots.

The value of mulches appears to be their ability to reduce surface temperature and increase soil moisture. Creosotebush distribution also suggests that a controlling factor is soil moisture and soil temperature. Calcium ion concentrations may be responsible for the failure of seeding trials on Site Two. High calcium ion concentrations may influence creosotebush spread, but are not the controlling factor.

Reference copy: Library of the New Mexico Institute of Mining and Technology

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The Use of Industrial Wastes as Fertilizer (Grant no. GY-10810)

Mercyhurst College
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June 11, 1973 - August 17, 1973

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The use of industrial wastes as a substitute for commercial fertilizer was investigated. A composite of three industrial wastes was made: Solution A (HNO_3) - a pre-plating, metal cleaning, rust inhibiting (pacification) treatment used in the metal plating, metal painting and metal coating industries; Solutions B(H_3PO4) and C (K_3PO_4), both used to etch printed circuit boards in the electronics industry. Each waste had previously been analyzed quantitatively for K, P, and N, as NO_2, NO_3, and NH_3. They were also analyzed quantitatively for Hg, Sn, and Ni, the only potentially toxic elements found by a complete qualitative cation and anion analysis.

This composite was applied to experimental field plots having snapbean, Phaselous vulgaris (var. Tendergreen), as a test plant, and to greenhouse pots having snapbean and oats, Avena sativa (var. Carolee), as test plants.

The yield of bean fruits from the field plots, in lbs/acre (Table I), the total yield of plants from the greenhouse experiments, and plant tissue analyses for essential elements were used to determine the ability of these wastes to supply the necessary plant nutrients: N, P and K.

Statistical analysis, using Duncan's Multiple Range as the test of significance on all yields, and the results of the tissue analyses, showed that the wastes did supply the three major plant nutrients as well as does a commercial fertilizer.

The plant tissue was also analyzed for the three toxic elements found in the wastes. No nickel or tin was seen in tissue samples of any experimental treatments. Small amounts (.3 to .7 ppm) of mercury were found in the plant tissue samples of all experimental treatments grown at the field test site. The heavy metal content of the wastes did not have any toxic effect on the test plants; however, heavy metals will accumulate in the soil with ecologically-disasterous consequences. The removal of all contaminants from the wastes before their use as fertilizer seems to be the most promising solution to this problem. The possibility of profitably recovering the contaminating metals for re-use could be an additional economic benefit.

A hydroponic study was undertaken to observe nutrient deficiency symptoms when the wastes were used to supply N, P and K. The plants with solution A as the sole source of nitrogen were badly stunted but did not exhibit any of the classical nitrogen-deficiency symptoms. The cause of this stunting was apparently the slightly higher ion concentration of this treatment.

The general toxicity of the composite was determined by observing its effect on seedling germination and growth, using seven types of seeds and various dilutions of the composite.

The soil used in these experiments was sampled before, during, and after the plant growth period. The results of these tests provided a basis for the determination of the amounts of plant nutrients used and showed that the soil stability was not appreciably changed by the application of the wastes.

All data were statistically analyzed, utilizing a computer.

The data prove that industrial wastes can be used as fertilizer and they suggest that the environment, industry, agriculture, and consumers would benefit.

Treatments	Replications 1	2	3	4	$\overline{X}_4$	*	Calc. Yield
Commercial fertilizer	23.7[b]	32.5	25.8	13.0	23.7	a	6451.99
Composite	20.2	28.7	27.1[b]	32.5	27.1	a	7374.48
Fertilizer & effluent	29.1	25.5	29.0	26.5	27.5	a	7469.51
Control	11.0	14.3	9.75	17.6	13.1	b	3570.61

TABLE I

YIELDS OF BEAN FRUITS FROM INDIVIDUAL FIELD PLOTS AND MEAN YIELDS (lbs) PER TREATMENT AND CALCULATED YIELDS (lbs/acre) ADJUSTING[a] TWO FIGURES[b] TO THE MEAN OF THE THREE OTHER FIGURES IN THOSE TREATMENTS.[c]

* Those means followed by a common letter are not significantly different at the 5% level using Duncan's Multiple Range Formula.

[a] PEARCE, S.C., Biological Statistics, McGraw Hill, N.Y., N.Y. 1965 (pp. 105-7)

[c] This was done to correct for low yields due to rodent damage.

Reference copy: Mercyhurst College Learning Resource Center

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Forensic Soil Analysis (Grant no. GY-10803)

Michigan State University
East Lansing, Michigan 48824

June 11, 1973 - August 31, 1973

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Physical evidence offers a convincing way of relating a suspect to a crime. The forensic analysis of soil samples for comparison and point-of-origin determinations has not been widely practiced in recent years, because of a lack of research.

This project was undertaken as a means of studying possible new techniques in forensic soil analysis for both the comparison and point of origin of a soil sample.

The problem was approached from four directions. The Physical Methods Group examined the problem from the aspect of the physical properties of the soil. They used classical techniques (color, density gradients) and a new collodial suspension test. They also tried some relatively new techniques (IR, and X-ray powder diffraction). The Chemical Analysis section made trace element analysis, utilizing atomic absorbtion and neutron activation. This group also attempted to compare soil samples by gas chromatography. The Biological Studies group tried to solve this particular problem by looking at the soil inhabitants, and by testing for carbon in the soil, as well as the percentage of organic matter and the pH of the soil. The Criminal Justice Group kept the other team members aware of what was happening in the criminal world. This group also performed the statistical analysis of the data from the other groups. These data were transferred to maps, so that visual representations would be available for quick reference, and so that correlations might be seen easily.

Several techniques were found to have both statistical and practical value. Tests were also rated by their sample size requirements, time involved, and cost per sample. A point-of-origin test was found by the statistician - a test which, hopefully, will provide a fast and reliable method of determining soil sample origin. Analysis of this test did not occur for lack of time; however, in theoretical testing, it appeared to have promise.

The problems of soil analysis for forensic purposes were not solved, but it is felt that this study has pointed out the need for additional research and has demonstrated some methods which, with refinement, will prove to be of value to the forensic scientist.

Reference copy: Science Research Stacks of the Michigan State University Library

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Public Service Delivery in Chicopee, Massachusetts (Grant no. GY-10756)

Amherst College
Amherst, Massachusetts 01002

June 11, 1973 - September 1, 1973

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Our study of the City of Chicopee's provision for public goods and services is based on an analysis of the City as a "firm" in the macroeconomic sense. Chicopee is producing a certain mix of public goods and services. For any level of output, it has a production possibility frontier--various alternative production levels for the various goods and services it might provide. We used analytical techniques from the fields of economics, sociology, political science, urban studies, engineering, and administrative and management theory to answer some of the following questions: 1) Could the City provide the same level of goods and services with less inputs? 2) Could the City provide a 'better' mix of goods and services with the same inputs? 3) Are there alternative municipal revenue schemes which are more attractive; either from an equity standpoint, or from the point of view of better allocation of resources between the public and private sectors?

To answer the third question, we studied the present municipal revenue structure in Chicopee (property taxation, excise taxation, billing for City utilities, such as water and electricity, and the alternative of user charges). We limited our study to municipal revenues that were controlled locally and so did not examine such programs as revenue sharing, which is exogenous to local determination of the total municipal revenue. Since property taxation brings in 62% of the total local revenue, and is totally locally controlled, it was the main subject of analysis. We determined that Chicopee's present property tax billing operation is of dubious legal status. The assessor's habit of recording assessments at 20% to 40% of true market value was probably illegal, inequitable, and arbitrary. At present, a Chicopee resident can expect to be assessed up to 30% more than his neighbor with an identical piece of property (or 30% lower). We could not discover any systematic assessment in favor of certain groups of people, although this would require a tremendous survey effort to determine any conclusive patterns. We concluded that one possible reason for Chicopee's present assessment operation is that fractional valuation allows them to get more money from the State in school aid than they otherwise would, but that this factor would probably be outweighed by a more equitable taxation system, and a better bond rating which would result from full valuation property assessments in Chicopee. We did establish that a number of municipal goods and services might be financed better with "user charges", as is currently done with water and electricity.

Considering the second question--Whether Chicopee could provide "better" services, or a "better" mix of goods and services, we resorted to a public opinion survey of 315 randomly chosen residents of the City. A city does not have the same sort of incentives to satisfy public demand as private enterprise. Elected city officials are supposedly kept in check by the electorate, people are allowed to express their opinion by ballot, and if the residents do not like their City's mix of services, or think taxes are exorbitant, they can cancel their elected officers in favor of ones who espouse more favorable viewpoints. Elections provide a very limited range of choices. In Chicopee, the voters rarely get a chance to vote on issues as such, but usually just for the candidates who have tied themselves to various viewpoints.

Since voting records are inconclusive in explicitly pointing out demand preferences for public services, we used the survey questionnaire to determine which public goods and services the people were satisfied with and which ones they were not satisfied with. We determined that, on the whole, most respondents were satisfied with most local services, by wide margins. The only exceptions seemed to be servicing and planning of the Chicopee road network, and the traffic problems it creates, dog control, and pollution abatement. The last of these, pollution abatement, is not usually considered a local public service.

Around 90% of the respondents were satisfied with education, police, and fire protection, the three biggest expenditure items in the municipal budget. There seemed to be a fairly strong feeling that too much money was going towards schools, perhaps at the expense of police, fire, and public works. When asked to rank public safety (police and fire), public works (utilities, roads, sewage and trash disposal), schools, and public health in order of importance, the average respondent ranked them in the following order: #1--public safety, #2--schools, #3--public health, #4--public works.

In answer to the first question--Can Chicopee provide the same level of services with less inputs--we analysed as many departments as our resources would allow. The Departments and programs studied include City Auditor, City Clerk, City Engineer, City Collector, City Hall Maintenance, City Messenger, City Treasurer, City Registrar of Voters, Central Purchaser, Fire, Forestry, Highway, Municipal Solid Waste Disposal, Police, Data Processing, and Public Health.

Our framework of analysis is derived from methods of rudimentary cost-benefit analysis. We attempted to compare the value of what a program was accomplishing with its costs, and as data were quite variable, the conclusions and degree of specificity varies considerably from department to department. Hopefully, our results will provide the groundwork for a municipal budget, where program costs are identified and quantified by program, rather than as a series of departmental line-item totals which have little relevance to specific departmental programs. We identified the various programs which the departments under study were undertaking, attempted to split them up along cost lines where possible, and compared the program costs to program benefits. The cost/benefit comparisons were usually made by looking at the private market value of services similar to the one under study and occasionally, by comparisons with programs in other cities similar to Chicopee.

The following is a summary of some of our program recommendations:

1) City Auditor: Start implementation of programmed budgeting, rather than line-item budgeting.

2) City Clerk: Allow outside analysis of City Clerk operations.

3) City Collector: Introduce computerized collection, billing, and record keeping, appoint City Collector, and/or merge office with Treasurer's Office.

4) City Engineer: Get more qualified personnel, merge with Highway Department into a Public Works Department.

5) City Hall Maintenance: Contract out for City Hall maintenance.

6) City Messenger: Contract out for City Messenger service.

7) City Registrar of Voters: Computerize all Department files.

8) City Treasurer: Contract out for payroll operations, appoint Treasurer.

9) Central Purchasing: Expand Department, establish Central Purchaser of Labor--Personnel Department.

10) Fire Department: More emphasis on preventive fire protection, more firefighter educational opportunities, more constructive use of the time spent in station, keep records of personnel and time allocations.

11) Forestry Department: Keep track of trees planted and trees cut.

12) Highway Department: Contract out for more municipal roadwork, merge with City Engineer into a Public Works Department.

13) Municipal Waste Disposal: Build College Park--cellulosic yeast digestion recycling plant.

14) Police: Keep records of personnel and time allocations, stagger cruiser changeovers, contract out for private ambulance service, computerize files.

15) Public Health: Evaluate program objectives, enforce inspection laws, contract out sample testing to private enterprise, increase environmental personnel, use personnel properly.

Our study examined the current municipal governmental structure as it relates to program efficiency. Since some programs are run by commission-headed departments, some by singled-headed departments, some by commissions without departments, and some by department heads with advisory commissions; and since there are a variety of commissions with only indirect relation to actual policies or programs, we felt it useful to examine the relation between the form of these various organizational structures, and what they were able to accomplish. In some cases, we recommended major changes, as with the Health Department, Library Department, and Cemetery Department, but in a number of cases, we did not see any major gain from reorganization, i.e., in the Police Department, Fire Department, Water Department, and Electricity Department.

Some departments were left untouched by our study, including the huge School Department which utilizes half of Chicopee's expenditures. There is a lot that could be done by City departments themselves to enhance objective analysis of their operations--keeping better records of what they are expending per program in labor and supplies.

The purpose of the resident preference survey was to identify the degree of satisfaction of the residents with the local public services they were receiving. Aside from covering many of the individual public services with specific questions, one of the main purposes was to ask some broad questions which would identify the overall priorities of the people of Chicopee. There seemed to be clear consensus that the public safety departments, i.e., Police and Fire, were the most important services. Fifty-one % of the 315 respondents ranked public safety first, compared to 20% for schools, the next most often picked. Still, one would not be able to infer from this fact that the City should expand public safety at the expense of schools and other services, because certain data, such as program costs, are avoided by this question. Schools receive close to half the municipal budget, and yet our survey would seem to indicate that they are second in priority to the public safety services. Since the residents of Chicopee are overwhelmingly satisfied with the education, police and fire protection they are receiving, one would gather that satisfactory public safety is only half as expensive to provide as satisfactory education. The conclusion that Chicopee residents would not like to see an expanded public safety program at the expense of their schools is further supported by a question where 37.1% favored the 'pie diagram' budget which most closely represented Chicopee's actual budget with relatively large school expenditures, whereas only 17.7% favored the "big public safety" diagram.

Although it is possible to say confidently that Public Safety is widely considered to be the most important of the locally provided public services, generalizations about the rankings of the three others listed, and the huge number of unlisted local services, are quite difficult to establish. On average (weighting first choice with 4 points, second choice with 3, etc.) one would conclude that the average respondent's ranking was: #1) Public safety, #2) Schools, #3) Public health, #4) Public works.

High rates of approval went to trash pickup, police, fire, schools, and emergency ambulance service. Relatively few people thought that the park system, or Library Department needed expansion, 92% of the respondents wouldn't consider moving to

Springfield or Holyoke for lower taxes. This supports the conclusion that residents are satisfied with life in Chicopee and, to a degree, the services they receive. There were a few services which were looked on favorably, but not by large margins. These included snow removal, which was satisfactory to 58% and unsatisfactory to 41%; condition of streets, which was satisfactory to 63% and unsatisfactory to 35%; and pollution, 35% thought that "present air and water pollution may be hurting their health" compared with 59% who didn't. Seventy-five % of the respondents felt that the traffic police were not helping these problems.

Two conclusions come out of looking at responses to the questions concerning politicians in City Hall: 1) Residents seem, on the whole, either apolitical or apathetic about Chicopee's politicians; 2) Chicopee residents seem to think that there is a fair amount of corruption in City Hall, although perhaps no more than in any other city or town.

The first statistical conclusion is more important to one of the general themes of our report: that Chicopee would be better off if it appointed a number of its presently-elected City officers, bringing more professionalism and qualified city management experience to jobs such as the assessors, the City Collector, the City Treasurer, and the City Clerk.

In an era where the speed of the decision-making and enacting process is becoming more and more vital, the importance of centralized administration increasingly outweighs the checks and balances of the electoral process, at least with respect to the local municipal offices of Assessor, Treasurer, Collector, and Clerk. Our survey would indicate that the people of Chicopee are not concerned about who is elected to these offices, or at least, not enough to remember their names for more than a year and a half. The City Clerk has been in office for over thirty years, and yet only 40% of the respondents could accurately name him. The Treasurer was named correctly by 23.4% of the respondents, the Collector, by 30.4%, and any one of the three assessors, by 43.4% of the respondents.

Concerning the "corruption" questions, it is unfortunate, but not too surprising, that residents do not exhibit more confidence in their municipal officials. There is a good possibility that the responses on these questions were affected by the national revelations on Watergate and other political mishaps. Chicopee residents may be expressing, in part, a disillusionment with politicians in general. In any case, it would be wise for City officials to strengthen their daily relationship with the people. According to our survey, 46.3% thought that Chicopee officials "don't listen to people", compared with 39.6% who thought they "did listen to people".

Part of the statistical analysis included an attempt to determine what sorts of people thought what kinds of things on the questionnaire. To determine whether certain demographic characteristics had noticeable effects on responses, we put together contingency tables to check responses of individuals against their age, sex, educational attainment, income, occupation, length of residence in Chicopee, family size, and ethnic or national origin. We tested our contingency tables with Pearson Chi-squared and Maximum Liklihood Chi-squared tests for row-column independence at 10%, 5%, and 2.5% confidence levels. We also computed the lambda statistic for predictive association.

To summarize the results, at the 5% level of confidence, age had significant effects on peoples' responses to political questions and the questions which asked the names of elected officials. Age affected responses on pollution issues. Older people did not see pollution as much of a problem as younger people. Age was also correlated with how people travel around town and their use of parks. Education related to views on political questions, the pollution questions, and resident satisfaction with public schools. Income affected responses on the police service, political questions, pollution, and additional money for parks. Sex made a difference concerning responses on some pollution questions, some political questions, and transportation around town. Length of residence in Chicopee was associated with significant changes of views on political questions, use of park services and travel around town.

In general, age and income levels seemed to have the broadest effects on peoples responses to the questionnaire. Education affected responses on a number of topics, but not as many as age and income. Sex had surprisingly little effect on responses.
Reference copy: Frost Library, Amherst College

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Economic Analysis of Competing Public Utilities in Jacksonville, Illinois (Grant no. GY-10812)

MacMurray College
Jacksonville, Illinois 62650

June 4, 1973 - August 10, 1973

Participants:

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Donald Larson*	John Wilson

*Student Project Director

Daniel Salomone, Faculty Advisor

I. Effects of Competition

A. Average Cost Comparison

Two regressions were chosen to represent the average variable cost functions of Illinois Power and City Light and Power. However, their explained variations are not as high as previous regressions because certain explanatory variable had to be omitted because of our inability to predict what their values would be at increased kilowatt-hour production. The base year of 1967 was chosen since it was the year for which the regression equations were most accurate. Average fixed cost was approximated by the sum of annual depreciation plus annual interest divided by kilowatt-hours produced.

Four average total costs were calculated: actual average total cost to Illinois Power in 1967; projected average total cost for Illinois Power; actual average total cost to City Light and Power in 1967; and projected average total cost for City Light and Power. The projected costs were based on the kilowatt-hour load each company would carry if it were to provide Jacksonville's entire demand. Costs were compared on two levels: average total costs and total costs. Both comparisons yielded similar results. Illinois Power could produce electricity for the entire city at lower cost than the two competing utilities can. On the other hand, due to large, but necessary capital investments, it would be more costly for City Light and Power to serve the entire city than for the two companies. However, both projected average total costs were respectively lower than the actual 1967 average total costs, indicating economies of scale in the production and distribution of electric power.

B. Survey of Jacksonville Electrical Customers

A questionnaire sent to local residential electric customers revealed that, while the privately-owned Illinois Power Company was generally regarded as having superior service, customers of both utilities had mixed emotions about selling City Light and Power. A commonly expressed view held that competition accounted for lower rates and better service in Jacksonville. While evidence gathered from other sources suggests that this is not the case, this view constitutes a social cost to be attributed to monopoly operation in the city and must be weighed along with other purely economic factors before a policy is recommended.

C. Waste of Competition and Market Analysis

The presence of two utilities in the same service area must inevitably result in a certain amount of duplication of facilities, especially in areas of distribution, collection, and administration. Our estimate shows considerable duplication of resources, both on a fixed asset basis and overtime in duplicated rents and salaries.

Using newspaper accounts and interviews, we also attempted to piece together the history of competition in Jacksonville, with special emphasis on the duopolists' price and non-price competition. It appears that the firms did not collaborate either on prices or service and that all agreements were tacit understandings. Illinois Power was clearly the dominant firm, setting its rates without regard to those of the City. Some free services were offered by both utilities and customers were encouraged to "switch" companies.

II. Effects of Regulation

A. The Averch-Johnson Hypothesis

Professors Averch and Johnson have presented the theory that utilities under rate of return regulation will tend to use excessive amounts of capital in order to "inflate" their rate base and, thus, increase the allowed amount of profit. Since Illinois Power experiences such regulation while City Power does not, we attempted to test the theory empirically. We verified, with three statistical tests, that Illinois Power's capital-labor ratio was, indeed, significantly different and larger than that of City Power.

Also, using regression techniques, we determined a logarithmic relationship between net income and the C-L ratio for Illinois Power, thus verifying the fact that higher input proportions of capital did increase the utility's net income. On the other hand, a significant relationship between net income and the C-L ratio for City Light and Power was not found. The evidence suggests at least a guarded acceptance of the hypothesis.

B. The Tax-Interest Differential

Federal and state tax laws offer distinct operating advantages to municipal utilities, as compared to privately-owned systems which must pay corporate income and other taxes for which the public systems are not liable. Also, since the interest from municipal bonds is exempt from Federal income tax, such bonds can be offered at a lower interest rate. We estimated that the savings from these advantages for the Jacksonville City Light and Power Department amounted to $345,861 for the year 1972. This constitutes the tax-interest "subsidy" enjoyed by the municipal utility. With regression analysis it was determined that the tax rate appeared to have a direct influence on the electric rates charged by Illinois Power, the privately-owned system in competition with the City, and may, in fact, account for the difference in the two utilities' rates. The evidence suggests that the lower interest rates on debt paid by the City may also have helped it to undersell Illinois Power, although to a much lesser degree.

Also, using a formula suggested by Wallace and Junk, the first authors to comment on the tax-interest differential, we estimated the production costs of providing peak power to Jacksonville with the actual facilities in use. The evidence suggests strongly that the tax-interest subsidy has encouraged the City to use inefficient sources of energy and, thus, has led to resource misallocation.

Reference copy: MacMurray College Library

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The Determination of Property Assessment Differentials in Metropolitan Philadelphia - With Emphasis in Delaware County, Pennsylvania (Grant no. GY-10759)

Swarthmore College
Swarthmore, Pennsylvania 19081

June 5, 1973 - August 28, 1973

Participants:

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*Student Project Director

Charles C. Gilbert, Faculty Advisor

The principal goal of the project was to determine the nature and extent of the differentials in residential property tax assesments. The main investigation was carried out in Delaware County, Pennsylvania, using a sample of about 1600 properties which were sold between 1970 and 1972. Information, including individual property characteristics, neighborhood variables, sales values and assessments, were gathered both from county records and from local real estate publications. An analysis was conducted using both regular multiple regressions and a two-stage least squares version (which accounted for the simultaneity of assessment and value determination).

Our econometric model explained a moderate portion of the variation with a high degree of certainty. The results showed systematic assessment variation from the mean assessment value ratio. Variations appeared on the basis of age of building, date of assessment, number of families in the structure, social status, racial composition of the neighborhood, number of bedrooms (size of house), local government jurisdiction, and other variables. Among the variables which were not significant, the most notable was party registration of the owner. Our variables covered the range of legitimate variables and the principal hypothetical discrimination variables. The relatively low R^2 which our model found indicates that there is a large random variation in individual assessments in Delaware County.

In addition to the econometric study, supporting work was done in economic, political, sociological, legal, and historical aspects of the assessment process and property taxation in general. The economic subgroup found substantial theoretical and empirical justification for radical alteration of the current property tax. On the basis of regressivity, horizontal inequity, inherent administrative difficulties, incompatibility with national economic goals, and tax base inadequacies, the economics subgroup concluded that the United States should move toward emphasis on a land tax and assessments assigned by multiple regression analysis.

The political-sociology group conducted extensive interviewing of local officials and reporters involved in assessment. They found extensive political involvement in Delaware County assessments and general inconsistency in assessment practices. Administrative theory was also reviewed in coming to the conclusion that assessment should be professionalized and should include vastly improved training of assessors, state certification of assessors, selection on the basis of merit, and standardized published procedures.

Statutory restrictions on assessment practices, recent litigation, and pending legislation occupied the attention of the legal specialist. Findings from this section were useful in contrasting current practices with proper practices. The research from this section also points toward the need to clarify and simplify administrative requirements and to resolve confusion in judicial standards and grounds for equity.

The history specialist sought to provide a perspective on property taxation and assessment, as well as to review historical, moral and scientific justifications for various positions on property taxation. The historian also assumed the responsibility for sketching the development of this project by way of an introduction to the report.

Reference copy: McCabe Library, Swarthmore College

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A Comparison of Interaction Patterns in an Open Space and a Fixed-Plan School (Grant no. GY-10752)

Virginia Polytechnic Institute and State University
Blacksburg, Virginia 24060

March 14, 1973 - December 31, 1973

Participants:

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Wolfgang F. E. Preiser, Faculty Advisor

The comparative evaluation of educational programs suggests the testing of the performance of students, most often by standardized achievement tests. Comparative evaluation of educational facilities usually tests the performance of the physical environment - light, sound, temperature. The dynamic interaction of the performances of the human and physical resources is rarely analyzed. Evaluation of this interaction in existing educational systems may provide behavioral and technical information for design criteria for schools.

An interdisciplinary research team of students from Virginia Polytechnic Institute and State University organized an ethological study to investigate some different interaction patterns which occur in an open-plan and a traditional, fixed-plan school. The objectives of the study were: (1) to investigate some interaction patterns among members of the school populations; (2) to examine some interaction patterns between the school population and the physical resources; (3) to study the physical systems as background to the educational environment; (4) to organize information to be used in developing design criteria for educational facilities.

Two public elementary schools, matched for educational philosophy, available resources, budget, and demographic description, were selected for the study. One school had a traditional design of self-contained classrooms. The second was an open-plan design. With the cooperation of the participating principals and teachers, remote-controlled videotape recorders were concealed from the students, and used to observe first and fourth-grade classes for four weeks. Recordings were made simultaneously in the schools, controlled for subject, time of day, and day of week. Data were taken from discrete time sample viewing of the tapes and recorded on standardized observation sheets. Videotape information was supplemented by informal interviews, observations, and measures of the physical environmental systems.

The results suggest three general conclusions: (1) the open-plan design appears to facilitate the interaction patterns of the school's philosophy better than the fixed-plan; (2) there is more use made of the available physical resources in the open-plan school; and (3) first-grade and fourth-grade interaction patterns may necessitate different design requirements. Reference copy: Cowgill Library, College of Architecture, Virginia Polytechnic Institute and State University

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Computer-Based Community Communications (Grant no. GY-10766)

University of Illinois at Urbana
Urbana, Illinois 61801

June 11, 1973 - August 24, 1973

Participants:

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Heinz Von Foerster, Faculty Advisor

I. Introduction

This project can be classified under two major headings.

(A) System development research

(B) Survey research

The purpose of the system development research was to implement prototypes of programs that utilize the PLATO system as a computer-based communications medium and define future approaches. The rationale for the survey research was to provide essential community input into the system development. Following is a description of the major accomplishments in both areas.

II. System Development

(A) Papers: As a result of the summer work, two papers have been submitted for publication. "Second Generation Conferencing Systems" argues that far more attention must be paid to system design goals if these systems are to be utilized by the general public. Four initial criteria are proposed. The paper was prepared for the 1974 National Computer Conference and Exposition. "Computer-based Community Communications" outlines eight computer-based methodologies for involving the public in the planning process. One of these methods, conferencing, is explored in detail. This paper was submitted to the Annual Association for Computing Machinery Student Paper Competition. Both papers were authored by George E. Carter, Student Project Director.

(B) Programs:

(1) Urban Dynamics -- Jay Forrester's urban model was implemented on PLATO. A citizen may run through the life cycle of an urban area on the terminal. He may also alter the model's parameters by trying out possible solutions to urban ills and observing the effects on the area's social and economic indicators.

(2) Interaction Matrices -- A sixteen-element self-interaction matrix has been implemented on PLATO that allows citizen participation in "New City" planning.

(3) Conferencing -- The "discuss", "confer" and "conference" programs have all been substantially improved. "Discuss"

has received extensive use.

(4) Attitude Measurement -- The "perceptions" program administers a questionnaire to each participant. He is then allowed to view the aggregate responses of all participants, permitting "reality testing".

III. Survey Research

The major tool employed for our survey research was a questionnaire. The universe was the residents of the twin cities of Champaign and Urbana, Illinois. A randomly-selected sample, consisting of 404 interviews, was obtained from July 9, 1973 through August 5, 1973. An intensive period of data analysis then followed.

Demographically, our sample was mixed. Nearly 90% of the sample was white, and 10% black. Females accounted for 58% of the sample, with over a third of our interviewees between the ages of 18 and 28. Over a quarter of the sample was raised in a small city (between 25,000 and 100,000 in population). Additionally, 60% were natives of the State of Illinois.

Nearly three-fourths of the sample had been educated beyond the high school level and, of those, fully one-third had completed more than 4 years of post-high school study. The two largest occupation groups comprising our sample were white collar professionals (25%) and students (23%). Moreover, 22% of the sample reported an income of better than $15,000 during the past year.

As far as the political preference of the sample was concerned, "Independent" was named by 38% of the sample, with "Democrat" being stipulated by 35% and "Republican" by 21%. Furthermore, blacks reported lower levels of income and educational achievement.

Those interviewed were asked to tell us their frequency of obtaining news through the various media, their media preferences for local news, and their opinion of the credibility, fairness, and completeness of each. They were also asked to respond to two statements concerning forms of communication, and to several statements which expressed differing views of technology.

Measures of the sample's political activity, feelings of political alienation and cynicism, and attitudes toward increased citizen participation in policy making were also sought.

Briefly, we found that our sample, as a whole, exhibited the following attitudes: Television, a visual medium, received more favorable responses than did radio, an audio medium, with newspapers, a printed medium, ranking last. All three media, however, were viewed in a favorable light. Additionally, television was the medium most often employed for the receiving of national news, with newspapers the one most often used for obtaining local news.

The sample reported feeling comfortable with both verbal and written communication. However, of the two, verbal communication projected the more favorable overall attitude. Our sample's attitudes toward technology were mixed, with many being unclear as to the meaning of some of our statements in this area. Additionally, a relatively high level of political activity, and relatively low levels of political cynicism and alienation were found in our sample.

IV. Conclusion

We are convinced of the potential of computer-based communications media for enhancing our quality of life. Future research should be directed at the following concerns:

(1) Developing the graphics capabilities of the PLATO system, particularly in conferencing programs.

(2) Utilizing PLATO's national network capability by encouraging users at remote sites to participate in conferences and by gearing issue programs to national concerns.

(3) Optimizing system performance through human factors studies.

Reference copy: University of Illinois Library

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The Effect of Government Involvement in Housing on Social Interaction in Communities (Grant no. GY-10750)

Providence College
Providence, Rhode Island 02918

June 24, 1973 - August 28, 1973

Participants:

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Stephen Misovich, Faculty Advisor

This study explored a hypothetical relationship between government involvement and its effects upon the social interaction pattern of subsidy recipients. The hypothesized effect was a negative one, i.e., increased government involvement in housing would be associated with a more restricted social interaction pattern.

All respondents in the study were female. Degree of government involvement was defined by a gradient system of government sponsored housing. Type 1 housing (high involvement) consisted of government constructed, monolithic housing projects. Type 2 housing (medium involvement) consisted of government constructed, dispersed housing, and Type 3 housing (low involvement) consisted of privately constructed, but welfare-supported housing units. A two-part questionnaire was utilized to explore the respondent's cognitions and evaluation of her housing situation, as well as her attitudes and behavior *vis-a-vis* social interaction and neighborhood use. Two separate data collecting techniques were employed. Initially, personal interviews were undertaken. Circumstances subsequently forced us to use mailed questionnaires.

Because of this change of technique and an extremely low response rate, the findings reported must be interpreted with a good deal of caution. Two major respondent differences were noted among the housing types. Clear differences were discovered between respondents' general attitudes about friendship and social values and their evaluation of the social atmosphere within their neighborhoods. Secondly, the day-to-day activities (e.g., visits to friends) of each housing type were significantly different. However, while Type 1 residents, as suggested, exhibited the most restricted pattern of attitudes and behaviors, the relative positions of Types 2 and 3 were the reverse of the hypothetical predictions: Type 2 residents consistently showed less restriction in almost all response categories.

Reference copy: Phillips Memorial Library, Providence College

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Energy Efficient Air Conditioning of Architectural Spaces by Self-Actuating Devices (Grant no. GY-10788)

University of Michigan
Ann Arbor, Michigan 48104

May 7, 1973 - July 31, 1973

Participants:

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*Student Project Director

A. Peters Oppermann, Faculty Advisor

Since non-renewable, energy-powered systems which rely on the continuous supply of fossil fuels are experiencing the effects of an "energy crisis", alternative solar energy-powered systems are becoming economically more competitive, along with being ecologically more desirable. Long-range solutions to this planet's escalating energy requirements and dwindling fossil fuel reserves are inevitable if we can develop sufficient solar energy-powered systems. The situation is best summed up in reflecting on some of the thoughts of R. Buckminister Fuller who once stated that the earth can be likened to a "spaceship" which travels with our solar system within what we know as the universe. Being similar to a spaceship, we live in a self-contained, life-supporting environment which is limited in the quantity and quality in its capabilities to sustain life. Since our non-renewable energy resources are earth-based and thus, inherently limited in nature, and since these fossil fuels were originally developed through the agency of the ultimate non-renewable energy source, our sun, steps taken to utilize solar energy directly and indirectly in powering solar energy-based systems will prove beneficial. This action may then provide the necessary long-range replacements for our endangered fossil fuel systems. Solar energy and its many varied forms, as, for example, wind and water energy, are potentially limited in usefulness only by our ingenuity, social commitment, and our rate of response.

Our automated natural cooling system, relying on the evaporative cooling of water and designed for the future application to residential-scale structures, was conceived as part of a total solar-heating and cooling system. Development of the cooling system received the primary emphasis because of time, personnel and budgetary constraints. Since solar heat collection systems are presently being marketed commercially and since application of several of these designs is possible to our natural cooling system, a solar heat collection system was relegated to a secondary role in this research endeavor.

The specific efforts of this research group have been directed along the lines of developing methods of harnessing solar energy and natural wind currents to produce useful heating and cooling of residential-scale structures. Since both of these processes need some measure of control to be practically useful, our design resulted in a special "double roof" system for our experimental structure, where the lower roof acts as the primary cooling surface and the upper roof becomes the heat shield for the lower roof and the primary heat collection surface.

Cooling wind studies were also made to establish the optimum orientation of the experimental structures with respect to the best capture of those winds available for the evaporative cooling process. The control of the cooling process was achieved through the use of bimetallic coils attached, by cable, to movable insulation panels located along the lower perimeter of the sloped double-roof system. These counterweighted panels shift up and down vertically in metal channels through the motion supplied by the bimetallic coils located on the upper roof. These coils curl and uncurl when subjected to solar/air temperature changes because of the physically bonding of two dissimilar metals, one having a high coefficient of thermal expansion and the other having a low coefficient. Housing these coils in glass boxes insures a greater coil response because of the build up of interior air temperature and better coil protection from the exterior weather conditions. Through the use of nylon pulleys and stainless steel wires attached to the coils and running down to the respective movable panels, we are able to create an automatically-actuated cooling system which "adjusts" the amount and velocity of available natural wind currents passing between the double roof system. Since the evaporative cooling obtainable has a one-to-one relationship with wind velocity, we found it desirable to explore ways of inducing a greater wind velocity as it was passing between the double roof system over the lower roof cooling surface. This surface is composed, from the top down, of four inches of water-saturated sponge, a plastic water barrier, and structural hardware cloth spanning the wooden rafters of the lower roof. By means of wind tunnel tests, the physical devices used to induce an increase in the wind velocity were inclined, land berms up, to the experimental structure which directed the wind upward, an overhanging roof which acts as an air scoop and a wall-shading device, a 15° sloped roof for water drainage and air flow characteristics, and a wind-powered and oriented revolving gravity ventilator at the crown of the upper roof for "sucking" the wind between the double roof system through the base of the ventilator to the outside. Through this combination of "funneling down" the wind at the intake areas along the lower perimeter of the double roof system, just above the walls, and a ventilator actuated "suction" action at the crown of the upper roof, a near doubling of the initial wind velocity can be achieved as it passes between the double roof system. This, in turn, will almost double the evaporative cooling obtainable. Water was pumped from storage containers to the crown of the lower roof for distribution to the sponge and the excess was collected at the lower end and returned to the storage containers. A twelve-volt pump was used, (since this is the only conventional, non-renewable energy-consuming piece of equipment within the experimental structure, a wind generator, upon which construction is almost completed, was chosed as a substitute.)

An additional material used to aid in maintaing a comfortable interior temperature was improved wall insulation. These employed large urethane foam "building blocks" which interlock and which have hollow cores for the pouring of a structural concrete framework.

Reference copy: Reference Library, College of Architecture and Design, University of Michigan

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Research into the Building of Algorithms to Evaluate Model Cities Programs (Grant no. GY-10804)

New Hampshire College
Manchester, New Hampshire 03104

June 4, 1973 - August 24, 1973

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*Student Project Director

Non-Stipend Participant:
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William Hunzeker, Faculty Advisor

The original objective of this study was to develop, through an interdisciplinary systems analysis of the Model Cities Agency of Manchester, New Hampshire, an evaluative model for social service agencies. Because evaluation of programs or services is merely a small portion of the effort of social agencies, the objective was later expanded to include the planning and budgeting methods needed to support the evaluative techniques developed in the study.

The work was conducted in three overlapping phases. Phase 1 was designed so as to complete an urban situation analysis by investigating and analyzing the present structure of social service agencies in Manchester and how it interfaces with the community. The greatest emphasis was on Manchester's Model Cities Agency and its operations. Using facts collected and assumptions made in Phase 1, a preliminary conceptual model was developed in Phase 2. The model was tested and the final report written during Phase 3. Testing was completed by randomly selecting two current Model Cities programs and by applying all methods and algorithms established in Phase 2.

Participants were required to work in two groups (qualitative and quantitative) as needed throughout the three phases. Matrix management techniques were used to provide cohesiveness and common direction between the groups.

The project was started with lectures in the various disciplines represented in order to establish an infrastructure of terminology and methodology. Various operations research tools, such as time-series studies, model building, cost-benefit analysis, cost-effectiveness analysis, and variance analysis, were utilized to complete a Planning-Programming and Budgeting System (PPBS).

Through the urban situation analysis, a long-range PPB System has been established that will provide social agency administrators and urban planners with an integrated four-phase system consisting of: 1) Problem Identification - designed to identify, assess, and rate urban problems using relationship matrices and indices, preference theory and utility theory, and social indicators/characteristics; 2) Alternatives Assessment - provides information on how to analyze social agencies and their methods in order to ameliorate problems, as well as the agencies' own alternatives, with such tools as objective and program profiles and organizational function delineation chart; 3) Program Budgeting - offers methods to select and analyze financially program alternatives and procedures for forecasting expenditures and possible revenues; and 4) Program Evaluation - utilizes cost analysis methods and underlines specific procedures and criteria for data collection and processing. An appendix is included in the final report illustrating the PPB System as it could be applied. A glossary of terms is appended to prevent confusion for the reader.

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Interviews with local government officials and social agency directors were conducted to gather data to test the validity of the model and algorithms developed as part of the resulting system. Social data were obtained from City, State and Federal offices and from the local Model Cities Agency to test the feasibility of the use of social indicators/characteristics in the Problem Identification Phase and for inclusion in the appendix. Program expenditure information was also obtained from Manchester's Model Cities Agency for use in the appendix.

The proposed system has received a favorable response from Manchester city officials and from the Director of the Model Cities Agency.

Reference copy: H. A. B. Shapiro Memorial Library, New Hampshire College

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Application of Modeling and Simulation to Design of Pollution Control Equipment (Grant no. GY-10769)

Manhattan College
Bronx, New York 10471

May 28, 1973 - August 24, 1973

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Louis Theodore, Faculty Advisor

This project was concerned with the evaluation of several types of air pollution control equipment. The equipment examined were the gravity settler, venturi scrubber, electrostatic precipitator, and fabric filter. For the gravity settler and the electrostatic precipitator, the effect of varying operating conditions on collection efficiency was studied, while, for the venturi scrubber and fabric filter, their effects on pressure drop was investigated.

The gravity settler was investigated to verify a mathematical model for collection efficiency proposed shortly before the project began. The model makes use of the Monte Carlo technique to assign a size and location to each particle entering the gravity settler. Force balances are made around the particle and its progress through the settler is monitored until it either escapes or is collected. Experimental data were collected on a bench scale gravity settler containing 21 collecting plates. Polystyrene latex was used to generate a monodispersed aerosol. Samples of the inlet and exit particulate concentrations were obtained with isokinetic collectors. A microscope was used to count the number of particles in the inlet and exit samples, and the collection efficiency was based on this. The conditions under which the test was run, gas flow rate, particle loading, etc., were fed into the model and solved on a digital computer and the predicted results compared to those measured. The experimental results were non-reproducible and no specific conclusions could be drawn. In general, however, it was agreed that the experimental technique, and not the model, was at fault.

A similar approach was used in the study of the electrostatic precipitator. The proposed model can be used to study the effect of precipitator length, plate-to-plate spacing, electric field strength, particle loading, and velocity profile on collection efficiency. The Monte Carlo technique was used to assign a size, location, and electrostatic charge to each particle as it enters the precipitator. A force balance was made around each particle and its progress through the precipitator monitored until it is either collected or escapes. The collection efficiency is based on the mass collected. Construction of a bench scale model precipitator was begun but has not yet been completed. The model was compared to collection efficiencies reported in the literature and was in close agreement in all cases. Electrostatic precipitator performance curves for typical pollutants in several industries are presented. The mathematical model can be used to simulate with a parallel plate or a tubular precipitator. For all the cases studied, the collection efficiency of the tubular precipitator was always higher than that of the parallel-plate precipitator.

The venturi scrubber was investigated to develop a mathematical model describing the pressure drop. The major cause of the pressure drop through a venturi scrubber is the transfer of momentum from the gas stream to the injected liquid in the throat. The equations were developed by selecting a central volume in the venturi scrubber and performing force and momentum balances around it. The major variables considered were the void fraction, liquid droplet size, gas velocity, liquid velocity, and venturi configuration. A system of four differential equations was developed and solved numerically, using the Runge-Kutta fourth order forward integration method. A relationship has been established between the void fraction at the entrance to the venturi throat and the liquid-to-gas ratio. Pressure profiles, as a function of position in the venturi, as well as overall pressure drops, are presented. In addition to the theoretical work, experimental pressure drop data were collected on a bench scale venturi scrubber. The pressure drops predicted by the mathematical model agree very well with those obtained on the bench model. The experimental results compared favorably with the small amount of data available in the literature.

The investigation of fabric filters began toward the end of the project. The causes of pressure drop through the filter were investigated and a preliminary mathematical model proposed. The model accounts for the pressure drop across the fabric, as well as the pressure drop across the filter cake. Some of the major variables considered are the porosity of the fabric and filter cake, the diameter of the fabric fiber, and the diameter of the particulates collected. Although the model has not been completed, specific examples are given to show how the parts may be used.
Reference copy: Grover M. Herman Engineering Library, Manhattan College

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An Analysis of the Effects of Sulfur Dioxide on Lichen Metabolism

(Grant no. GY-10799)

Bethany College
Bethany, West Virginia 26032

May 28, 1973 - August 17, 1973

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A field survey was used to determine the type and amount of lichen growth at 36 sites along the Ohio River from Moundsville to New Manchester, West Virginia, concurrently evaluating the amount of sulfation for each survey site and 138 additional sites.

The mean percent coverage for the 36 sites was 6.26 with a standard deviation of 4.69. The following table summarizes the areas of low lichen coverage and indicates the probable sources of air pollution affecting them.

Site Number	Percent Coverage	Source of Pollution
1D	3.05	Toronto Power Plant
10D	1.05	Weirton Steel
13D	1.80	Kopper Coke Plant
15D	2.40	Kopper Coke Plant
19D	2.80	Wellsburg Industries
21D	0.70	Wellsburg Industries
22D	1.70	Wellsburg Industries
24D	0.20	Cardinal Power Plant

Site Number	Percent Coverage	Source of Pollution
29D	0.40	Tiltonsville Industries
32D	2.50	Wheeling Steel
35D	3.70	Wheeling Industries
37D	2.20	Wheeling Industries
39D	5.50	Wheeling Industries
41D	1.61	?
44D	1.47	?
46D	2.57	Moundsville Industries
47D	5.39	Moundsville Industries

After comparing the locations of the sulfation sites with the known sources of pollution and with the lichen coverage obtained from the survey site, it was concluded that an error was made in either the construction or analysis of the sulfation plates.

A controlled study was made of the morphological changes of various species of lichens and two species of algae, when exposed to different levels of sulfur dioxide. The development of a biological indicator for sulfur dioxide was the end result sought.

The lichens used in the exposure experiment showed varying degrees of sensitivity to sulfur dioxide. The experiment also indicated which lichens would be best suited for use as indicators of pollution.

The lichen, Cladonia coniocraea, was found to be a good demonstrator of pollution in the more polluted regions. Since the sulfation data proved to be inaccurate, the coverage of C. coniocraea was related to the total site average of all lichens found. This site average is a good indication of the quality of the air. The equation of the regression line was $Y = 0.36 + 0.49X$, where Y is the square root of the average percent coverage for

C. coniocraea and X is the site coverage. The regression line has a correlation coefficient of 0.9439.

A study of the relationship between the amount of phaeophytin-a produced in an algal cell and the amount of sulfur dioxide in the atmosphere, using chromatographic and spectral analysis, was a third element of the project.

There was found to be no relationship between the amount of sulfur dioxide in the air and the amount of phaeophytin-a in the algal cells.

It is very likely that the phaeophytin-a found in the cells of the unexposed cultures was produced during the extraction process.

A radiochemical investigation of a-hydroxysulfonate inhibitor (glyoxylate bisulfite) formation in algal cells exposed to various levels of sulfur dioxide comprised the final area of study.

It was not possible to obtain disintegration counts significantly above background counts. It was not feasible to obtain or produce $S^{35}O_2$ carrier free and, therefore, it was possible that the glyoxylate bisulfite was formed but did not contain enough radioactively-tagged sulfur atoms to be significant, given the resolution of our counting system.

Reference copy: Bethany College Library

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Pollutants in San Diego County (Grant no. GY-10820)

University of California at San Diego
La Jolla, California 92037

June 25, 1973 - September 14, 1973

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Alan M. Schneider, Faculty Advisor

The purpose of this investigation was to complete an in-depth pollution study of Mission Valley which was selected because of its geography (a rectangular valley with contour lines approximately parallel to incoming wind streamlines). It was also selected because of the heavy development in the area which included many large freeways. The County of San Diego does not operate an air monitoring station in the vicinity, so the study provides a badly needed data base for future research efforts.

The pollutants successfully monitored were nitrogen dioxide (NO_2), carbon monoxide (CO) and particulate matter. Wind, temperature and humidity data were also recorded. In addition, a study of damage to pinto bean plants as a result of air quality and site characteristics was conducted. Time-lapse movies and photographs using different filters and film types were taken to capture the growth of smog-related haze.

Seven-hour samples of NO_2 at eight sites were collected for a period of two months. The equipment consisted of monitors built by the group according to specifications found in the Federal Register, Vol. 36, No. 228, November 25, 1971. The analysis technique used was the sodium hydroxide calorimetric method. Ambient concentrations of carbon monoxide were sought at four sites. The equipment consisted of portable air pumps calibrated to fill aluminized mylar sample bags in a period of one hour. The bag contents were analyzed on a Beckman infrared analyzer. Particulate matter was sampled with electrostatic aerosol samplers and high-volume samplers. The data were reduced and analyzed by computer.

Results indicate definite increases in NO_2 and CO levels correlated with distance inland from the ocean. The raw data show a range of between 2 and 35 PPHM for NO_2; CO between 2 and 6 PPM, with average values of 3 to 10 PPHM NO_2 and 2.2 to 2.9 PPM CO from the furthest west to furthest east station. Two models were developed to explain this phenomenon, based on "varying-source" and "accumulation" representations. Particulate matter levels over a period of three weeks gave 39 $\mu g/m^3$ as the average value, low compared to the Secondary Federal Standard of 150 $\mu g/m^3$ over a 24-hour period. Electron microscope pictures of particulates were obtained for relative size determination.

Elemental analysis using a microprobe analyzer showed that zinc, iron and copper were present in the samples.

The plant damage study showed that PAN and ozone levels, along with site characteristics (including humidity and solar radiation) were sufficient to cause damage. Bronzing on the underside of the leaves due to PAN and white lesions due to ozone, were photographed on the plants, and compared with standards from the Riverside Air Pollution Research Center located at the University of California at Riverside. The most damaged site was in Mission Gorge, northeast of Mission Valley. Mission Bay was the least damaged by ozone, but suffered wilting from salt spray. All sites, except Howard Johnson, showed PAN damage; Mission Bay had but one leaf with a waxy underside.

The photographic study was unable to record successfully the formation of haze on time-lapse film to any marked extent. The slides, however, did show differences in the accentuation of haze, according to the filter and film used. Infrared Ektachrome with no filter gave the best results over other filter/film combinations.

The summer of 1973 showed CO, NO_2, and PM levels in Mission Valley comparable to levels recorded in other parts of the county. Trends for pollution distribution indicated an accumulation or settling effect which produces higher concentrations inland. Parallel winds along the major source of pollution, Highway 8, could account for this accumulation effect. Decreased mean wind speeds up the valley could account for the settling, or worse ventilation characteristics, of inland cites. Characteristics of the air quality were significant enough to cause damage to pinto bean plants.

More work needs to be done to determine long range pollution levels on a continuous basis to establish seasonal, daily and yearly trends. Further investigation into reasons for plant damage as a function of site characteristics should also be pursued.

Reference copy: Science and Engineering Library, University of California at San Diego

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Missoula Valley Air Pollution Study (Grant no. GY-10811)

University of Montana
Missoula, Montana 59801

June 18, 1973 - September 7, 1973

Participants:

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The 1973 Missoula Valley Air Pollution Study consisted of four areas of work. The respiratory disease study, and the hydrogen sulfide and sulphur dioxide determinations were a continuation and expansion of earlier work. The carbon monoxide sampling, and lead particulate determination were projects begun during this year's study.

An examination of respiratory patient visits to physicians (May, 1972 through November, 1972) showed correlations between pollution and climatological conditions, and the incidence of respiratory disease; however, it was concluded that a more controlled study of the patients was needed to provide any definitive answers.

The investigation of respiratory disease admissions to St. Patrick's Hospital in Missoula is still in the process of being programmed, and will not be ready for analysis and conclusions for several months.

Hydrogen sulfide and sulphur dioxide monitoring was conducted in and around the Missoula Valley, with over 400 samples collected. The method of West and Gaeke was used for SO_2 analysis, and the modified method of Jacobs, et al. for H_2S analysis. With only a few exceptions, low levels of sulphur dioxide were detected. Hydrogen sulfide concentrations were generally higher, with some samples up to .17 ppm.

Carbon monoxide monitoring was performed with an Ecolyzer from Energetics Science, Inc. Sites representative of the downtown, residential, congested traffic intersection, and free-flowing traffic areas were selected for continuous stationary sampling. At selected points on a predetermined grid of the city, short-term samples were also obtained. Significant correlations were found between CO levels and the volume of traffic, and CO levels and lead.

Particulate lead and total particulate samples were taken simultaneously at the four primary sites used in the carbon monoxide study. The samples were gathered with a high-volume air sampler, using glass fiber filters. The analysis was made according to the USPHS method; significant concentrations of lead were found. An atomic absorption spectroscopy method for analysis was also worked out.

Reference copy: University of Montana Library

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Computer Studies in Air Pollution (Grant no. GY-10747)

University of California at San Diego
La Jolla, California 92037

June 26, 1973 - September 18, 1973

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A statistical model was developed for the prediction of changes in oxidant air quality, as a function of location resulting from the creation of a complex source or the implementation of a land use or transportation plan. Geocoded reactive hydrocarbon emission inventories from mobile and stationary sources in Los Angeles and San Diego for 1969 and 1970 were used, with wind data and observed oxidant air quality, to calibrate a relationship between emissions and air quality. This relationship, applied to San Diego, was then used with a 1975 nominal case-geocoded emissions inventory to generate a nominal 1975 oxidant index as a function of position. A new geocoded emissions function was developed, incorporating the predicted effects of changed land use, and this, in turn, was used to generate a new 1975 oxidant function. The difference between the new and old oxidant functions represents the effect, area by area, of the change in land use on air quality. To demonstrate the capabilities of the model, an analysis was made of the effects of a proposed large scale development currently under environmental review by the County of San Diego. Information supplied by the applicant was used to develop a spatially-distributed emissions source function for the project. The resulting predicted change in oxidant air quality, measured by the number of additional hours each year that the Federal oxidant standard would be exceeded, was displayed as a function of position over the air basin. Quality change requires only modest amounts of computer time.

In addition, 1970 U. S. Census data and air quality measurements for Los Angeles County were combined to yield a comparison between average air quality and several socio-economic factors. Air quality measurements were taken in the form of daily averages for five pollutants at each of 15 monitoring stations. These values were interpolated to form a continuous air quality "surface" over Los Angeles County. The five different pollutant surfaces were than combined with a weighting scheme developed at Oak Ridge National Laboratory to yield an air quality index surface. The surfaces for individual days were averaged over the entire year, resulting in an average air quality index surface.

The socio-economic data, extracted from 1970 Census returns, were aggregated from about 1500 tracts comprising up to 35 homogeneous statistical areas. The average air quality surface was then integrated over each of the 35 areas, and compared with the socio-economic data for those areas. Results include relative quantities of different age, income, and racial brackets, as well as correlations between air quality and housing value, population density and income.

Reference copy: Science and Engineering Library, University of California at San Diego

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The Distribution of Pentachlorophenol in the Environment and its Effects as a Pollutant (Grant no. GY-10809)

University of Southern Mississippi
Hattiesburg, Mississippi 39401

June 4, 1973 - August 11, 1973

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Pentachlorophenol is a popular wood preservative, widely used for telephone poles, fence posts, and other wood products. Its distribution in the environment was studied by examining soil, water, and stream-bottom sediment from sites which are, or have been, exposed to the chemical. The effects of the pollutant, pentachlorophenol, on the environment were studied through standard bioassay techniques (LD_{50}) and field studies conducted at "penta" treating plants. A microbiological investigation was incorporated into the field studies to determine what bacteria inhabit the holding ponds of treating plants.

Distribution of pentachlorophenol (PCP) in the State of Mississippi is perhaps widest through its use in the treating of telephone poles. Soil samples were taken by a core method from a number of poles dating from 1949 to present, and analyzed for PCP content (mg PCP/5 g soil). PCP was found to move laterally "out" from the treated pole at a faster rate than it leached into the soil from the pole; this phenomenon is caused by the specific soil texture of our area which is predominantly loamy.

Samples of water and stream-bottom sediment were taken from three plant sites. At one site where tidal action was present, PCP levels were higher upstream than down. PCP was found to concentrate in the sediment and return to the water when heavy rains stirred the bottom. Fish kills have become more common after periods of heavy rains in streams near PCP treating plants.

Perhaps the most noteworthy results attained by the PCP analysis portion of the project were the successful adaptations of a procedure, used previously only with wood samples for the analysis of soil and water samples, and the perfection of a PCP purification method for the production of PCP of 99% purity.

In the laboratory, LD_{50} values for channel catfish were set at 0.12 ppm for reagent grade PCP (96% purity) and at approximately 0.14 ppm for commercial grade PCP. These figures represent the concentration of PCP which is lethal to 50% of the population. No previous references could be found for the two grades of PCP; the bulk of prior research has been done with a salt, sodium pentachlorophenate.

Field studies indicated a definite decrease in benthonic and nektonic forms below PCP plants, except where tidal action was present in the stream. Sampling was performed with a Peterson dredge (benthic and sediment samples), seines and dipnets (nektonic), and a sewage water sampler.

Microbiological techniques were employed to grow cultures of bacteria obtained from a plant waste lagoon for identification. During testing, cultures showed little reaction to varying PCP concentrations. By biochemical and staining procedures, the bacteria studied were shown to be the genera, Pseudomonas, Alcaligenes, and Serratia. The PCP level of the waste lagoon was 21 ppm, while cultures showed few effects at 17 ppm.

Reference copy: Cook Memorial Library, University of Southern Mississippi

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Properties and Utilization of Small Particulates in Cattle Manure

(Grant no. GY-10744)

University of Nebraska
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May 28, 1973 - August 17, 1973

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The objective of this project was to contribute to the development of a process for the utilization of cattle manure. This process is based on the vibrating screen filtration of slurried manure, producing a refeedable silage-like filter cake and a filtrate. The project group's efforts were directed mainly on the filtrate fraction--to characterize it in order to suggest possible methods of utilization.

The University of Nebraska Department of Agricultural Engineering operates a pilot facility, a housed feedlot (200 head capacity equipped to demonstrate the process mentioned above. Samples of filtrate were obtained from this facility throughout the project. Samples of unfiltered slurry and of fresh manure were also obtained here. The materials were transported to the lab in five-gallon carboys and, if not intended for immediate use, they were refrigerated.

Areas of investigation can be categorized according to whether they dealt with determining filtrate properties or with examining a possible method of utilization. More specifically, the former category includes a series of routine chemical analyses on the raw materials, an examination of the viscosity and density of filtrate, and a particle size determination. The latter category includes a field test of fertilizer quality, filtration experiments, sedimentation experiments, examination of chemical coagulants, fermentation experiments, and feeding trials.

The chemical analyses were based on standard methods developed for the determination of waste water and/or soil samples. Many of the procedures were performed (by one of the participants) in a USDA-associated analytical laboratory run by the University of Nebraska Department of Agronomy. The following procedures were performed: % dry matter, nitrogen (Kjeldahl, NH_4, and NO_3), ash, chemical oxygen demand (COD), pH, conductivity, phosphorus, micronutrients (Na,K,Ca,Mg,Fe,Mn,Cu,Zn) and amino acids. Average values for the most important quantities are presented in the table below, together with the standard deviations.

Type of Sample	No. of Samples* Analyzed	% Dry Matter (DM)	% Crude Protein** (Kj.Nx6¼)	% of the Kj.Nitrogen		%Ash**	COD (lb/lb DM)
				NH_4	NO_3		
Fresh Manure***	3	22.0 ±3.0	27.7 ±2.9	23.1 ±1.0	less than .01% for all samples	13.2 ±1.0	1.68 ±.16
Unfiltered Slurry	6	7.4 ±1.0	36.4 ±2.1	33.7 ±4.0		18.4 ±1.3	1.52 ±.12
Filtrate	20	5.9 ±.8	45.0 ±3.6	34.7 ±4.4		23.1 ±3.0	1.57 ±.05

* Except in the case of NH_4 nitrogen, for which the analogous numbers are 2,3, and 11 respectively.

** On a dry matter basis.

*** Collection method is questionable.

Viscosity and density of the filtrate were determined in order that design calculations could be made. Density measurements, using a volumetric flask in a constant temperature bath, were made at 0°, 22°, and 39° C, and it was found that the density was, for all practical purposes, the same as for water. Viscosity, on the other hand, varied considerably from that of water. It was measured both as a function of temperature (13.5-39° C) and of composition (2.5-10.0% dry matter). Results using a Stormer viscometer give values 8-10 times that of pure water for the normal (5%) concentration, ca. 30 times higher at 10% dry matter, and 4-6 times higher at the lower concentrations (2.5-3.3%), where the viscosity was fairly constant with temperature.

Particle size distribution of the filtrate was determined through use of a modified Coulter counter. Particles suspended in an electrolytic solution are drawn through a tiny aperture. The resistivity across the aperture is proportional to the volume of the particle. Most particles in the filtrate were found to be within one of three size ranges. These ranges, along with the percentage of total dry matter which each can be expected to represent: 0-5 μ (35-40%), 34-50 μ (24-28%), 79-96 μ (33-40%).

The fertilizer quality comparison between filtrate and the unfiltered slurry was carried out on 18 10' X 10' test plots which were planted with an early maturing forage corn. The recommended level of chemical fertilizer was 150 lbs. nitrogen/acre. Treatment rates used were: chemical fertilizer (KNO_3)--150 #N/acre; filtrate--150, 450, 900, 1800, and 3600 #N/acre; slurry--800, 1600, and 3200 #N/acre. In general, filtrate proved to be a moderately available fertilizer, with a high plant uptake of nitrogen and good yield at 450 and 900 #N/acre, but also with severe salt burning in low spots and at higher application rates. On the other hand, unfiltered slurry proved quite innocuous, with only slight NH_3 toxicity at 3200 #N/acre, and no burning. Yield performance of slurry at all rates was comparable to the chemical fertilizer control, and post-harvest soil nitrate was higher. Use of filtrate as fertilizer can be effective, but will require greater caution than use of unfiltered slurry. Also, high rate land application as a vehicle for disposing of large quantities of manure will pertain much more to the slurry than to the filtrate.

Vacuum filtration experiments were carried out in the laboratory using undiluted, unfiltered manure, and a Buchner funnel fitted with a 64 mesh stainless steel screen. The manure was slurried and then run through the filter, using a vacuum of 100 mm Hg Filtration rates were measured as a function of time, and curves obtained were seen to divide into three distinct regions. In the first 20 seconds, the filter resistance was controlling, and the filtration rate was very high, allowing a filter cake about 3mm in thickness to build up. The next 8 minutes was a transient period, and after that, the filter cake resistance became controlling and the filtration rate was very low. A design calculation, based on a 10,000 head feedlot and a 12-hour operating day, was made for a rotary drum vacuum filter with an effective filtration time of 20 seconds, i.e., just in the time region where filter cake resistance is not significant. The required filter area would be on the order of 500 ft^2, but would vary considerably depending on assumptions made. Such a filter would have a capital cost (including mixing tanks, feed tanks, and pumps) of $65,000-125,000. Even the worst conceivable assumptions would cause only a doubling in the upper limit cost. This would still be a relatively small investment per head capacity.

The apparatus for the sedimentation experiments was a pyrex column 4" ID x 8' total depth. It was filled with filtrate at the beginning of a run, and samples were drawn at selected time intervals through five 2mm capillary tubes which extended from the top of the column down to five evenly spaced test depths. The effect of filtrate dilution was examined. Filtrate concentrations were: 1.7, 3.4, and 5.6% dry matter. Higher concentrations were not possible as the apparatus could not pull out samples. A group of three runs were made, each over a one-week period, and for each concentration the percentage reduction in concentration was plotted as a parameter against time and depth of the sample. This parameter can be graphically integrated with respect to depth at any given time to obtain the percentage of the initial dry matter above a given depth which had settled below that point. After 24 hours, there were 23, 5, and 2% of the solids settled past the 6' depth for the 1.7, 3.4, and 5.6% concentrations, respectively. The 48 hour results -- 33, 8, and 5%. The 120 hour results -- 34, 15, and 13%. These do not say anything about the compaction of the sediment, however, and the increased settlability of the 1.7% material is offset by the dilution effect.

Compaction was found in another set of experiments to be reduced as the filtrate became more dilute. A 4% dry matter filtrate gave 11.7% dry matter in the sediment, while a 5% filtrate gave a 14.0% sediment, both representing about 40% of the total dry matter. The experiments noted were a comparison of chemical coagulants, done by centrifuging the treated filtrate and examining the supernatant and sediment fractions obtained. A broad spectrum of chemicals and commercial coagulants were tried. The best results were obtained using C-5 (a polyelectrolyte made by Rohm & Haas) at the 10% level based on dry filtrate. Compaction of the sediment was actually less (9.1% compared to 13.1%) than for no treatment, but the proportion of the dry matter which was in the sediment was much higher (70% compared to 40%). This treatment level would, however, be too high to be economical in practical usage.

Fermentation of the filtrate was carried out using a 5 liter benchtop fermenter. This was a non-sterile, batch operation, growing the organisms already present in the filtrate, and amounted to little more than an aeration procedure. Operating conditions were chosen from common practices in the fermentation industry and were kept generally constant from run to run. Eight runs were made, with times varying from 24 to 120 hours. Excessive foaming characterized the fermentation, and a high level of antifoam was required--silicon at no less than 5% of the dry filtrate weight. On a silicon-free basis, the fermentation product varied from the initial filtrate in these respects: 10-15% reduction in total dry matter; 95% reduction in NH_4 (more than half of which was assimilated into protein), corresponding 20% reduction in Kjeldahl nitrogen and increase to about 40% (from 30%) in the organic protein; some NO_3 production; 42-53% reduction in COD; digestibility was somewhat better. This crude fermentation presents the advantages of improving the feeding value and dewatering characteristics of the filtrate at a relatively low cost because of non-sterility. The major problems are combatting foam and obtaining FDA approval to feed this unidentified myriad of organisms.

The feeding trials were predicated on in vitro measurements using an artificial rumen technique as practiced in the University of Nebraska Department of Animal Science. In vitro dry matter disappearance (IVDMD) is an index of digestibility. Results for the filtrate itself were: 72% if wet sample is used, 54-61% for dried samples. IVDMD was also determined for five different feedstuffs which had been ensiled with either water, filtrate, or chemically treated (NaOH, Na_2O_2) filtrate for 14 days. Use of the filtrate, as opposed to water, improved digestibility only in the case of corn cobs. Treating filtrate with NaOH improved IVDMD except for alfalfa hay, but Na_2O_2 had little effect.

Three groups of four sheep each were fed isonitrogenously supplemented rations based on ground corn cobs ensiled with I-water, II-filtrate, III-filtrate + 3%NaOH (dry wt). After a 10-day acclimation period, feces and urine were collected for 5 days. For I, II, III, in vivo digestibility was 63.7, 65.4, 67.8%; nitrogen digestibility was 69.9, 65.4, 67.8%; and nitrogen retention was 19.5, 18.3, 15.8%. High variations between sheep made it obvious that the number per group was far too small, and the results may not be entirely valid. However, it is apparent that filtrate was utilized by the sheep, and since it allowed reduction by ¼ in the amount of supplemental soybean meal, its use is certainly attractive from an economic viewpoint.

Reference copy: Love Library, University of Nebraska

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The Hana Rain Forest Project (Grant no. GY-10792)

University of Hawaii
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May 21, 1973 - August 13, 1973

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The Hana Rain Forest Project presented the opportunity to design and conduct what has turned out to be one of the most significant field ecological research projects in the history of the State of Hawaii. The study area encompassed approximately 2½ square miles of rain forest and alpine grassland from 4900 feet to 8900 feet on the northeast slopes of Haleakala Volcano on the island of Maui.

From early June to mid-December, the study involved over 1000 man days of living and working in parts of the Upper Hana and Koolau Forest Reserves, probably two of the wettest areas in the world with extrapolated annual rainfalls of over 400 inches. Access to the study area was by helicopter only in good weather or by backpacking fourteen miles each way above 7000 feet.

Through the study of epiphytes, mosses, vascular plants, insects, mammals, birds, scils, meteorology, ecology and vegetation ecology, the Hana Rain Forest Project is producing an environmental reference work designed to provide State and Federal agencies, as well as private organizations, with the information needed to preserve and protect this unique area.

Research was conducted in four major ecosystems. Approximately 300 acres of Deschampsia grassland extends from Haleakala ridge tops at 8000 feet down to about 7300 feet. From 7300 to 7100 feet stretches a long narrow band of shrub scrub characterized by Vaccinium and Rubus thickets. The dense, wet predominately Metrosideros forest extends four to six miles from here down to the pastures and guava thickets above the Hana Highway. Interspersed throughout the study area from 5000 feet to the middle of the grasslands are Carex bogs underlayed with trecherous lava tubes and populated with beautiful greenswords and Lobelia. In the upper reaches of the forest are Lakes Wai Anapanapa and Wai Ele'ele. The former is technically only a pond, while the latter is one of Hawaii's two true lakes.

Three recording hygrothermograph stations and 36 rain gauges were maintained from early June through early December. Rainfall estimates varied from 146 inches at 7000 feet to 438 inches at 5000 feet. The highest recorded rainfall intensity was 17.4 inches in 24 hours. Studies were also done on fog drip and cloud patterns.

To date, the bulk of the bryoflora have yet to be classified; however, 13 families, including two very rare mosses, have been worked up. A total of 49 families, including 136 species of vascular plants, 121 of which are native, have been included in a preliminary checklist of the vascular plants of the Upper Hana and Koolau forest reserves. Among the specimens as yet unclassified are about nine new species.

The entomological research was designed to provide a general understanding of the insect fauna and some of its ecological roles. Considerable work was done on the insects of the East Maui Greensword, thought to be extinct until more than 5000 specimens were found by project members. It was discovered that the larvae of a tephritid fly was infesting the apical meristems of nonblooming greensword plants. The presence of the larvae caused the young leaves to become sealed together in a conical shape, forming a shelter over the meristematic tissue on which the larvae feed. The amount of damage done runs from severe stunting to no apparent effect at all, and is possibly a function of the extent of blooming at the time of infestation.

The following mammals (all exotic) were in the project study area: feral pigs, feral goats, feral cats, small indian mongoose, rats, and the house mouse. The overall limiting factors for each rodent species are most likely: adverse climatic conditions; availability of food resources; and interspecies competition for food and nesting sites. Predators were scarce and their effect on the rodents was negligible. Goats were found only in the upper *Deschampsia* grassland portion of the study area. The places most drastically affected by the goats are the inside walls of the summit. Here *Sophora* tree-shrubs can be found growing only on cliff faces and other such areas inaccessible to goats. The project has recommended to the National Park Service that the feral goats should be totally eliminated from Haleakala by whatever practical means which does not affect the natural aspects of the native ecosystem. The Service has already taken preliminary action to fence the entire park and hopes to hire additional personnel for feral animal control. Feral pigs were found throughout the study area. The shrubland below Puu Alaea was literally laced with hundreds of pig trails which increase gully erosion during heavy winter rains. Based on the data collected this summer, it is evident that pigs apply a detrimental pressure on certain of the areas studied. The project will recommend to the Department of Land and Natural Resources and to the National Park Service that control measures such as poisoning, chemosterilants, or intensive hunting should be considered for use in Hawaiian Forests.

The purpose of the soils research was to characterize and classify the various soil types of the study area with special emphasis on the bogs. The investigation included a physical description of the soils sampled and characterization by chemical analysis.

Prior to the Hana Rain Forest Project, the Upper Hana and Koolau Forest Reserves had not been explored ornithologically. During the study new methods had to be developed for population counts in this dense forest. Notes were made on bird feeding habits and preferences. Also, significant work was done on the breeding biology of the Maui Creeper about which nothing was previously known. The native bird fauna as a whole was most remarkable in that all but one of the native forest birds ever recorded on Maui were sighted. Undoubtedly one of the most striking achievements of the project was the discovery of a new bird. When codiscoverers Tonnie Casey and James Jacobi first presented drawings of the unidentified bird to professional ornithologists, it seemed incredible that in 1973 a totally new species existed. The most astonishing aspect is that, prior to this discovery, no new forest bird had been found in Hawaii since before the turn of the century. A technical description of the new bird is being prepared for publication by Casey and Jacobi with the assistance of Dr. Dean Amadon of the American Museum of Natural History, the recognized authority on the taxonomy of Hawaiian Honeycreepers. The bird will be the only known member of a new genus of the family Drepanididae which is restricted to the Hawaiian Islands.

The ecological study of the Hana and Koolau Forest Reserves is far from complete as many lifetimes could be spent observing and analyzing this unique native rain forest, one of Hawaii's last. We hope however, that our achievements will encourage further research in the area. The final report of the Hana Rain Forest Project should be published in book form within a year and, as such, is expected to become the major reference work on the ecology of montane rain forests and bogs in Hawaii. Reference copy: Hawaiian and Pacific Collections of the University of Hawaii Libraries

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The Collection and Integration of Land, Water, and Recreation Data Used in Resource Planning (Grant no. GY-10817)

University of Wisconsin at Stevens Point
Stevens Point, Wisconsin 54481

May 28, 1973 - August 17, 1973

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It was the intent of our study to collect data on the water chemistry and biology, sediment chemistry, soils and vegetation, and waterfowl use of the areas surrounding the Big Eau Pleine

Flowage and Lake DuBay, Wisconsin; and to ascertain the recreational use of these water bodies to see whether a correlation existed between these major concentrations of study.

The two water bodies were found to differ quite drastically in their water quality. The Eau Pleine has a nutrient concentration greater than that of Lake DuBay, while Lake DuBay suffered much greater oxygen depletion.

The plankton analysis found both bodies of water to be very productive and could be rated as eutrophic. Eau Pleine was found to have two times the amount of phytoplankton as does DuBay, while the numbers of zooplankton were greater in DuBay than Eau Pleine. Blue-green algae were the dominant type in both reservoirs. Diurnal studies of oxygen and CO_2 changes support the conclusion that the Big Eau Pleine Reservoir is more highly productive than Lake DuBay. Quantitative estimations of phytoplankton and zooplankton populations, chlorophyll a, and other productivity measures were made. Multiple linear regression analysis revealed that temperature light penetration, and nutrients (especially nitrogen and phosphorus) were the major factors controlling phytoplankton quantities and successional trends.

The greater phytoplankton population in Eau Pleine was found to be an important factor in maintaining a high surface dissolved oxygen value in this reservoir, while Lake DuBay had a surface dissolved oxygen content of only 0-4ppm.

BOD_{20} values for Lake DuBay and The Wisconsin River seldom exceeded 10ppm. COD values were 5-6 times higher, indicating a different type of loading than the Eau Pleine, which had BOD_{20} values from 14-25ppm and COD values of only 2-3 times this figure. The Big Eau Pleine Flowage had high surface dissolved oxygen values with steadily declining dissolved oxygen values as the bottom was approached because of decomposition of the plankton; Lake DuBay is characterized by low surface and low subsurface dissolved oxygen values due to lower plankton populations and heavy organic loading of incoming water.

At present, Lake DuBay has sufficient oxygen demand-reaeration conditions that its dissolved oxygen content is below the 5ppm minimum water quality standard. The Eau Pleine Reservoir maintained more than 5ppm dissolved oxygen during the study, but has higher BOD values than DuBay. This would indicate potential oxygen depletion, whenever algae die or when the reservoir is frozen, as is common in other highly eutrophic bodies of water.

In the sediment study of the test areas, it was found that an increase in silt plus clay was associated with an increase in the percent of carbon. Nitrogen levels in Lake DuBay were higher than the Eau Pleine and were correlated to the percent of carbon in the sample. Available phosphorus levels were also associated with areas of high organic content and silt plus clay.

The soil mapping portion of the project mapped a total of 9,100 acres. The soils ranged from loessial silt deposits of variable depth to lusrustrian silts and sands underlain by stratified outwash material. The soil survey encompassed all land areas within 1/4 mile of the Big Eau Pleine Reservoir. Based on the capabilities of individual soils, we constructed 3 land-use limitations maps. Once completed, these maps revealed that the most serious hindrance to the normal development of the Big Eau Pleine is the problem of sewage disposal. On-site treatment of human waste by septic systems is not recommended in 44% of the survey area, while the remaining 56% of the land area is marginal for this use. Careful management should allow some limited cottage, commercial and industrial development where these uses demand sewage treatment facilities.

Limitation ratings for low building construction of slight and moderate comprise 89% of the area and 97% for campsites. If some attention is given to site selection, the Big Eau Pleine Reservoir and the land area surrounding should become a valuable recreation resource.

Additional information used in placing land suitability for the activities noted above was based on data collected through the vegetation analysis. Detailed cover maps were constructed within 100 feet of the shoreline of both water bodies. These should be of value to planners in utilizing land aesthetics for future development.

Another broad topic covered by the study was the waterfowl survey. Four species of ducks: mallard, blue-winged teal, green-winged teal, and wood duck were using these water bodies. Broods of all except green-winged teal were observed. Mallards make up 68% of the broods, the blue-winged teal 20%, and the wood duck 12%. Three cover types: 1) cattail-bulrush-sedge; 2) cattail bulrush-sedge with emergent grasses; 3) wooded islands were evaluated for waterfowl use.

A total of 500 interviews were taken for the tourist survey at 11 sampling points within the study area, and 84 interviews were taken of residents in the study area. The greatest concentration of tourists occurred on weekends, when campgrounds in the area were crowded, often to capacity. The DuBay area tended to draw visitors from longer distances than the Eau Pleine. Tourists also spent more money in the DuBay area, especially within one mile of the shoreline. The Big Eau Pleine area generally received higher ratings for water recreational quality than the DuBay area. Persons rating water quality as high tended to give similar ratings for the recreational opportunities in the area.

Reference copy: Library, University of Wisconsin at Stevens Point

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Rat Control: An Interdisciplinary Approach (Grant no. GY-10764)

Beaver College
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June 1, 1973 - August 24, 1973

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In an effort to control rats by means of chemical rodenticides, much research has been aimed at studying the effect of various toxic additives to the diet of rats. Our experiment was directed along this line of research. Griffith and Farris (1963) state that females who eat food supplemented with doses of vitamin B_1 or manganese cannibalize their young. We repeated this study with some modifications to see which of the two compounds was the most effective and at what dose level.

There were six experimental groups and one control group of four females each. All of the experimental groups received a minimum of one of the three concentrations of Vitamin B_1 (.07g/days, .14g/day, .29g/day) or manganese (.07g/day, .14g/day, .29g/day) in the food. The vitamin B_1 groups also received a minimum of .07g of B_1 in the water supply. These concentrations were modified from an earlier study by Perla and Sandberg (1939). The control group remained on a normal diet. During the final week of the experiment, autopsies were performed on a portion of the rats. At that time, stomach, gonads, and adrenal glands were compared for any anatomical changes or aberrations.

The results showed a higher incidence of cannibalization of young with the experimental lactating female rodents on the two highest concentrations of vitamin B_1 and manganese in the diet than the control lactating female rats on a normal diet.

Percentage of Cannibalism

Vitamin B_1		Manganese	
.07g/day	0%	.07g/day	0%
.14g/day	31%	.14g/day	28%
.29g/day	21%	.29g/day	19%

Control group - 0%. Average nine pups per female rat.

We are continuing with inferential statistical analysis of this data. The autopsies showed stomach aberrations (thin walls, white covering of stomach) and large adrenals on some of the animals in the experimental groups, when compared with the control rats.

The research that has been carried out on effects of high-frequency sounds on rat behavior has opened tremendous possibilities for the use of sound as a means of disrupting social organization. High frequency sounds seem to be a form of communication among rats. Meyers (1968) classifies the use of high-frequency sound as a rat control measure under "promising but insufficiently developed techniques."

Based on Calhoun's design, the experimenters constructed a colony pen which housed twenty-four wild rats. They then set up equipment to monitor the high-frequency sounds (20 to 50 kh) made by the rodents, according to Sales (1972), and Barfield and Geyer (1972). The wild rats were observed over a three-week period, during which the experimenters correlated social behaviors with the high-frequency sounds emitted by the rats. Social behaviors included aggression, play, and mating behavior. Most of the high-frequency sounds emitted by the animals were from 20 to 26kh.

The experimenters then introduced high-frequency sounds from 50 to 50kh into the colony pen for a period of a week. The introduced sounds were "stationary" or on a "slide" from higher to lower frequencies. The sounds were artificially produced with a Hewlett-Packard oscilloscope. The introduction of high-frequency sounds had a disruptive effect. Fewer rodents were out to be observed by the experimenters than were during the three-week observation period and fewer social interactions took place. When high-frequency sounds (sliding or stationary) were introduced into an area where the rats were out, the animals moved from the area or exhibited fighting behavior. Autopsies were performed on a number of the rats to examine for stress (adrenals) during the three-week observation period and the week after the high-frequency sounds were introduced into the colony pen. A higher degree of stress was found in the rats from the week after the introduction of high-frequency sounds than the rats from the three-week observation period.

Understanding of rats' individual and collective behavior in a colony, says Davis (1972), is a necessary prerequisite for effective control. The results of his study in Baltimore, where he disrupted the normal social behavior of city rats through the addition of dominant males, led Davis to the conclusion that the addition of dominant male rats to a rat colony disrupts the social behavior of that colony. There are many effective rodenticides, e.g., warfarin, red squill, but the knowledge of the danger of the bait says Lorenz (1966) is transmitted throughout the rat colony, and is passed on from generation to generation. Relating Meyers' and Lorenz's findings to the results of his Baltimore study, Davis states that the best strategy for controlling rats is not to introduce one method of control, but to combine several controls at a time. Based on these findings, this experiment looked at the effect of the rodenticide red squill in a wild rat colony after the colony was stressed and disrupted by the addition of strange rats into the colony.

Three groups of wild rats (a control group, experimental group, and a donor group (strange rats) were housed in colony pens in a semi-natural environment. The experimenters observed the wild rat colonies for three weeks to establish baseline behaviors, e.g., sleeping, eating, fighting, etc. At this point, autopsies were performed on a portion of the rats from the experimental and control colonies to establish a physiological baseline. Strange rats from the donor colony were then added to the experimental colony to induce stress. Twenty-four hours after adding the strange rats and continuing for a one-week period, the experimenters administered a lethal dose of red squill in the food of both the experimental and control colonies.

All the strange rats introduced into the experimental colony died within a period of three days. Only one of the resident rodents (a pregnant female) of the experimental colony died. Two rats from the control colony died within a period of three days. The autopsies performed on these rats failed to determine whether the rats died primarily from the rodenticide or fighting.

The fourth aspect of the rat control project dealt with community attitudes towards rats. It is our feeling that, in the past, various attempts directed toward the control of rodents have been incomplete. Extermination of rats has been carried out without regard to the question of why the rat populations were originally present and able to maintain their existence in the community; whether it be due to objective causes such as an unlimited food supply and burrow material, or simply subjective causes such as indifference among community citizens.

A survey consisting of demographic measures, internal-external orientation, informational scale, methods of rat control, subjective expected utility (a measure of values and expectations) and an observational checklist was made in two rat-infested communities, one of upward mobility and the other of downward mobility, in Montgomery County, Pennsylvania. The independent variable involved the behavioral measure as determined by verbal reports, as well as an observational evaluation by the interviewer. The dependent variables were internal-external orientation, information level and subjective expected utility. The experimenters hypothesized that the subjects who tended to use more approved methods of rat control would also be internally oriented, have a higher informational level, and have higher expectancies of a rat problem than the subjects who did not use approved methods of rat control.

The results showed the downward mobility community to be more aware of the rat problem and more actively engaged in rat control methods than the upward mobility community. The downward mobility community, though actively involved with the rat problem, was limited in results because of the lack of support or concern from the local government. The subjects also showed a preference for various rat control methods. There were only two methods that the subjects tended to like more than dislike; having rats leave the property and die, and the use of high-frequency sounds. The use of chemicals to induce the mothers to eat their pups resulted in approximately equal responses of like and dislike. Any method leaving the rat dead or alive on the property was disliked. The use of poisons were also disliked due to accidental poisoning of other animals and children.

The results suggest all these experiments as future useful methods of rat control. The results of the experiments also suggest that a combination of rat control methods is by far the best way to deal with the problem.

Reference copy: Beaver College Library

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Land Use Alternatives for Mark Creek West (Grant no. GY-10757)

Sonoma State College at Sonoma
Rohnert Park, California 94928

June 4, 1973 - August 12, 1973

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Mark West Creek was chosen as the study area because it is the last remaining natural waterway in the Santa Rosa Valley. We felt that if we could spend enough time studying the Mark West Creek watershed we might be able to better understand how a natural waterway functions, and its importance to the people in the area. With this knowledge we could present alternatives to creek channelization and, perhaps, help preserve Mark West Creek.

The goals of the project were as follows:

1. To study the Mark West Creek watershed from the following perspectives:

    a. Biological
    b. Planning
    c. Economic
    d. Educational

2. To discuss our findings with landowners and other interested parties at a series of public meetings and to answer or re-direct questions that arise from these meetings.

3. Present our findings in a publication that, hopefully, will be of assistance in future planning decisions made in Sonoma County and elsewhere.

Our first objective was to become familiar with the varied characteristics of Mark West Creek by surveying the creek, determining its intrinsic suitability for a range of alternative land uses, photographing the diverse characteristics of the creek including aspects of the biotic community, and taking inventory of the plant and animal life (aquatic, riparian, and terrestrial). Distributional data for both the fauna and flora associated with the Creek form an extended section of our final report. Recorded are the occurrences of seven different creek "areas" of 25 microscopic plants and animals, and of 49 macroscopic invertebrate and vertebrate forms.

We talked to residents along the creek, and learned how it related to the people. To some, the creek was taken for granted with little understanding; to others, it was "their creek"; but to most of the residents, Mark West Creek had a personal meaning to them, its irreplaceable scenic amenities, its abundance of natural wildlife and the "calls" of the riparian wilderness. During the third week of our study, we went to Chico to compare the land use planning of Bidwell Park (a large linear park along Chico Creek), and how it was financed and maintained. We also obtained information on creek management in Sacramento, at the University of California (Davis), agencies in San Francisco, and various local agencies. It was found that the local agencies had the most influence upon the direction of creek development.

When it was discovered that the Sonoma County Water Agency had been working on plans for building a 300-foot dam in the upper Mark West Creek above Mark West Springs Lodge and/or channelizing the lower reaches in the flood plain, our group came to a consensus that the direction of our study be changed.

In conjunction with the Sierra Club, we set up a display at the Sonoma County Fair. We also held public meetings in a local elementary school auditorium with the residents of the Mark West Creek watershed and made arrangements for personnel from the Sonoma County Water Agency, Planning Commission, Public Works, North Coast Water Quality Control Board, State Fish and Game, County Parks and Recreation, Santa Rosa Planning, etc., to speak at one of three community meetings to inform the people what their agencies are doing, and what we were doing. These meetings were highly successful, with attendance ranging from 75 to 150 people.

Our findings can be summarized, as follows:

1. Mark West Creek is the last remaining natural waterway in the Santa Rosa Valley and as such, it is a unique, valuable and endangered resource.

2. Natural streams represent less than ½% of the land area of Sonoma County, yet they are the most important areas in terms of wildlife and fisheries habitat, and scenic value.

3. Increased social and political awareness is important to insure continuing survival of this natural waterway.

We have made the following recommendations:

1. Sonoma County should take immediate steps to adopt an ordinance which provides maximum protection and enhancement of natural waterways and requires protection and restoration of streamside vegetation.

2. Governmental agencies with jurisdiction over the stream should coordinate efforts to insure maximum protection and enhancement of natural waterways.

In addition to the results obtained and mentioned in our reports, several other effects of our study should be mentioned:

1. Parts of our study are incorporated into the Staff Report for the City of Santa Rosa Planning Department in their implementation of a Northern Open Space Buffer focusing on the preservation of Mark West Creek (November, 1973).

2. A riparian ordinance with a setback requirement is being enforced by the County.

3. Our project director, Calvin Ares, is currently a paid legislative aid for the 3rd District Supervisor and is working on a riparian ordinance.

4. The residents living along Mark West Creek are informed about the effects of excessive development and the dam and channelization proposals and many of these residents are willing to organize to express their concerns.

5. Our group have given slide show presentations to the Mark West Elementary School P.T.A., and to the local chapter of the Sierra Club, and we have acted as naturalist guides to a 6th grade elementary school classroom field trip on Mark West Creek.

Reference copy: California State College at Sonoma Library and the Santa Rosa-Sonoma County Public Library.

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A Consultative Study of Occupational Safety and Health for the City of Tuskegee, Alabama (Grant no. GY-10777)

Auburn University
Auburn, Alabama 36830

June 13, 1973 - August 24, 1973

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The Occupational Safety and Health Act of 1970, Public Law 91-596, provides that each employer shall "furnish to each of his employees employment and a place of employment which are free from recognized hazards that are causing or likely to cause death or serious physical harm to his employees." Federal, state, county and municipal employers are exempt from this law and thus not bound to this statue. However, if the state legislature, upon approval of the Federal government, passes a law equal or more stringent than the Federal Occupational Safety and Health regulations, then the state, county and municipal employees are covered and the employers must comply to that state's Occupational Safety and Health standards.

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The purpose of this report is to prepare for Tuskegee municipal government officers the means to evaluate present operations and facilities with regard to providing safe and healthful working conditions for municipal employees. Although not forced to comply with Federal OSHA laws, a safety program based upon these established standards would provide the City of Tuskegee with a reliable and enviable program. It would also establish a safety organization which could readily be converted into a State-operated and enforced occupational and safety law.

This report encompasses the Tuskegee, Alabama, municipal employee operations and working environments observed and documented by this research group during the summer of 1973. The members of the teams were from Auburn University and Tuskegee Institute.

Each city department, operation, and building was evaluated three times, once each by three teams, for the following hazards:

1. Housekeeping
2. Electrical
3. Fire
4. Environmental
5. Operational
6. Vehicle

Each team's report was evaluated and compiled into one final report, complete with recommendations to correct unsafe situations.

Information used as the basis for recommendations are taken primarily from the Codes of Federal Regulations of Federal Occupational Safety and Health Standards. Other sources include the

National Electrical Code, American National Standard Practice for Industrial Lighting, and Motor Carrier Safety Regulations.

Following are the conclusions reached by the group and its recommendations:

1. The evidence secured during the course of our research indicated that the need for an effective accident prevention program is significant. All areas observed had at least one or more violations in the six basic hazard areas outlined in the report;

2. While these violations usually did not qualify as an eminent danger (risk of immediate death), the violations remained a serious threat to the employees' health and/or safety;

3. In most instances, housekeeping hazards could be eliminated relatively easily, primarily through pick-up and clean-up campaigns conducted at regular intervals;

4. Electrical hazards were due primarily to overloaded electrical receptacles, ungrounded wiring systems in buildings, and broken grounding plugs on electrical cords;

5. The replacement or procurement of sufficient fire extinguishers of the proper weight and class and the proper mounting of these extinguishers would eliminate most of the fire hazards. Marking exits properly and providing obstruction-free exits would eliminate a great deal of the remaining fire hazards;

6. Protective shielding for welders, improved light intensities, and various personal safety equipment for all workers would eliminate most of the environmental hazards. Some machinery guarding by mechanical means is needed, however;

7. Periodic training for employees by qualified personnel and the strict enforcement of safe operating practices is primarily needed to eliminate operational hazards;

8. All vehicles in every department needed at least some minor repairs before they could be considered as safe. Every department had vehicle-related hazards that could be quickly (and relatively inexpensively) remedied;

9. The lack of a suitable accident reporting system greatly hampers the prospect of identifying accident-prone areas within municipal work areas;

10. The basic costs of the recommendations within this report are relatively low for capital outlay. Many of the recommendations may be fulfilled through the use of city personnel. The recommendations that do require some cost are few and the capital outlay is small compared to the increased benefits to both the employees and the city department.

Reference copy: Ralph B. Draughon Library, Auburn University

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Ecological Stability and Persistence of Natural Meadows and Man-made Grasslands in Southern California (Grant no. GY-10791)

San Diego State University
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June 11, 1973 - September 1, 1973

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Processes affecting the stability and persistence of a natural meadow and man-made grassland (chaparral to grass type conversion) were measured in order to ascertain the relative degree of permanence of these systems. Water supplies were found to be significantly higher at the natural meadow because of the geomorphological features of the area. Native perennial grasses appear to be restricted to these moist environments. Soil nutrient supplies of nitrogen were similar between the systems, but soil exchangeable potassium was significantly higher and soil available phosphorus was significantly lower at the natural meadow. The former discrepancy is apparently due to water retention and added inputs at the natural meadow, while the latter is principally because of the alluvial nature of the meadow soil and uptake by the perennial grass. Herbivore pressure at the natural meadow is completely absent because of low grass palatibility and low preference by the Black-tailed Deer, Odocoileus hemionus, which frequent the area. Black-tailed Jackrabbits, Lepus californicus, and Brush Rabbits, Sylvilagus bachmani, exert heavy pressure upon planted grasses at the type conversion, due to grass palatibility and creation of habitat favorable to expansion of populations. Deer are absent from the area because of the lack of preference for grass as a food source or other advantages in use of the area. _Eriogonum fasciculatum_ (Flat-top Buckwheat) is becoming established at the man-made grassland, yet it is restricted to the edge of the natural meadow due to differing water regimes and the removal of restricting factors upon its growth that are present in the chaparral. The natural meadow is seen to have an environment significantly different from that of a man-made grassland, both in physical and biological attributes. In view of this, it is doubtful that the planted perennial grasses will be able to persist and maintain a viable community.

Reference copy: Malcolm Love Library, San Diego State University

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A Kinetics Study of the Sulfur Species in Smelter Emissions

(Grant no. GY-10801)

University of Arizona
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Summer, 1973

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The copper industry of Arizona produces one-third of the world's supply of this metal. Because of increasing needs for copper in the electronics and other industries, it would be disastrous if the major producers were forced to shut down because of environmental pollution.

Arizona is presently facing this problem. On the one hand, copper is a large economic factor in the support of the State; on the other hand, the principal smelting method uses copper sulfide ores which release large amounts of sulfur dioxide gas into the atmosphere. This sulfur dioxide emission is the cause of great alarm for many individuals and organizations, both in Arizona and nationally.

The present study, successor to two NSF-SOS-funded projects at the University of Arizona which examined air pollution, is an investigation of the reaction kinetics involved in the sulfur species present in the plume emitted from a copper smelter.

The objectives of the study were directed towards the empirical determination of concentrations of sulfur dioxide, sulfur trioxide, sulfuric acid and particulate sulfates as a function of position from the source of the emissions (smelter). These data, when combined with meteorological information and time of day, were compared to the theoretical concentration profile generated by operational information from the smelter and the Sutton dispersion model. From these comparisons, and from a kinetic study of the sulfur dioxide to sulfur trioxide conversion, a mathematical model of the chemical system has been derived.

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Environmental Impact Statement on Recreational Land Development: Factual Forecast Study Group (Grant no. GY-10790)

Western Washington State College
Bellingham, Washington 98225

June 11, 1973 - August 31, 1973

Participants:

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At the Federal level, legislation and policy governing land development have, at best, been vague and disorganized. As one goes down to the state and local levels, the situation becomes alarmingly chaotic and irrational. A lack of direction is evident partly because of the absence of laws, policies and leadership working in the public interest, and partly because of the ignorance of land management practices on the part of the citizenry that is responsible for misguiding our energies and efforts into destructive channels. The lack of communication between developers, government agencies, and the public at large has led to confrontations and hostilities resulting in court actions and closures. The public is often ignorant of the natural, economic and sociological impact that development may have on their communities.

The increasing demand for recreational facilities and housing has led to a plethora of poorly planned developments that have had a devastating effect on our environment at the expense of the surrounding community. This has formed a damaging image of recreational developments, making it difficult for even well-planned projects to pass public scrutiny and to gain community acceptance.

Man's environment includes both social and natural processes, which must be evaluated on a common scale. The ecological principles that apply to natural systems may be applied to social systems; and the economic system must place value on preserving the balance of nature. In the long run, the most economical path is also the most sensible ecologically. As the economic and legal machine is refined to include all external costs and benefits, the governing system will approach an environmentally sound status that keeps the public interest foremost in its priorities.

In this project, a group of eight students with expertise in biology, water quality, geology, engineering, human ecology, environmental planning, and economics studied existing recreational developments. The objective of the preliminary survey was to observe present planning techniques and to ascertain the possible effects on the environment. Extensive interviews with government officials and community representatives provided further information. From all these sources, the team formulated initial guidelines to be used by the community, governmental agencies, and developers in the planning of recreational developments. To facilitate the use of the guidelines, the recommendations have been made according to the stages of development. Following are the preliminary guidelines:

1. Site Location. The selection of the land to be developed

should be based on comprehensive land-use factors. The choice of a site seriously affects the regional use of recreational resources.

2. Pre-Construction Period. Includes all preliminary planning of site design, based on intensive surveys of the natural features of the site. An Environmental Impact Statement must be filed at this stage, with a scale model of the site design available for public comment.
3. Construction and Sales Period. Special engineering considerations must be made at this time to avoid disruption. Alternative methods to the usual approach to land development sales should be sought.
4. Post-Construction Period. Encompasses the stage of habitation, the evolutionary period that the development goes through, from vacation homes to a permanent, full-time community.

It is the intent of the group that these guidelines be used by public as well as private entities to open corridors of communication, thus increasing the understanding of public needs. The consideration of all aspects of man's environment, and the use of these considerations as a decision-making tool hopefully will result in developments which are more environmentally sound, and in a wiser approach to land and resource management.

Reference copy: Huxley College of Environmental Studies, Western Washington State College

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